HANDBOOK OF BALLISTIC AND ENGINEERING DATA FOR AMMUNITION

VOLUME I

VOLUME II

JULY 1950

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BALLISTIC RESEARCH LABORATORIES

ABERDEEN PROVING GROUND, MD.

HANDBOOK OF
BALLISTIC AND ENGINEERING DATA
FOR AMMUNITION

VOLUME I

20-I-95 to 75-I-310 incl.

JULY 1950

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BALLISTIC RESEARCH LABORATORIES HANDBOOK OF ENGINEERING DATA

Preface

For a number of years, the Ballistic Research Laboratories of Aberdeen Proving Ground have been making measurements of the characteristics of projectiles, propelling charges, etc. While these data are available in various Ballistic Research Laboratories reports, there is no single document which contains a concise tabulation of all the available information concerning the respective articles which have been subject to measurement. It was pointed out by Colonel H. H. Zornig that the utility of the information would be considerably enhanced if all acquired data were collected in a single document. Following Colonel Zornig's suggestion, the preparation of a handbook of such engineering data as are available at the Ballistic Research Laboratories has been initiated.

The first numbers written by Mr. H. P. Hitchcock deal with projectiles. Later additional series pertaining to propelling charges, guns, etc., will be prepared.

The number of an item in the handbook consists of three parts. The first part indicates the caliber, e.g., 6 in. or 155mm; the second indicates whether the item is a projectile, a propelling charge, or a gun; 1 denoting a projectile, 2, a propelling charge, and 3, a gun. The third part indicates the model (Arabic) or mark number (Roman numerals). Thus 155-1-III refers to the 155mm projectile MK III while 3-1-42 refers to the 3" shell M42.

TABLE OF CONTENTS

VOLUME I — 20-1-95 TO 75-1-310 INCL.

	BRLH No.	Paragraph Nos.
Shot, AP, 20-mm, M95	20-1-95	1- 8
Shell, Incendiary, 20-mm, M96	20-1-96	1- 7
Shell, HEI, 20-mm, M97	20-1-97	1-10
Shot, APC, 37-mm, M51	37-1-51	1- 8
Shell, HE, 37-mm, M54	37-1-54	1-11
Shot, APC, 37-mm, M59	37-1-59	1- 9
Shot, AP, 37-mm, M80	37-1-80	1- 9
Shell, HE, 40-mm, Mark 2	40-1- 2	1- 9
Shot, AP, 40-mm, M81 or M81A1	40-1-81	1- 8
Shell, HE, 57-mm, M306	57-1-306	1- 9
Shell, HEAT, 57-mm, M307	57-1-307	1- 8
Shell, HE, 60-mm, M49A2	60-1-49	1- 6
Shell, Illuminating, 60-mm, M83A1	60-1-83	1- 7
Shell, Smoke (WP), 60-mm, M302	60-1-302	1- 7
Shell, HE, 75-mm, M41A1	75-1-41	1- 8
Shell, HE, 75-mm, M48 and M48E2	75-1-48	1-14
Projectile, APC, 75-mm, M61A1	75-1-61	1- 8
Shell, HEAT, 75-mm, M66	75-1-66	1- 9
Shell, HE, 75-mm, M309	75-1-309	1- 8
Shell, HEAT, 75-mm, M310	75-1-310	1- 8

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 20-1-95

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
15 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shot, AP, 20-mm, M95
with
Tracer

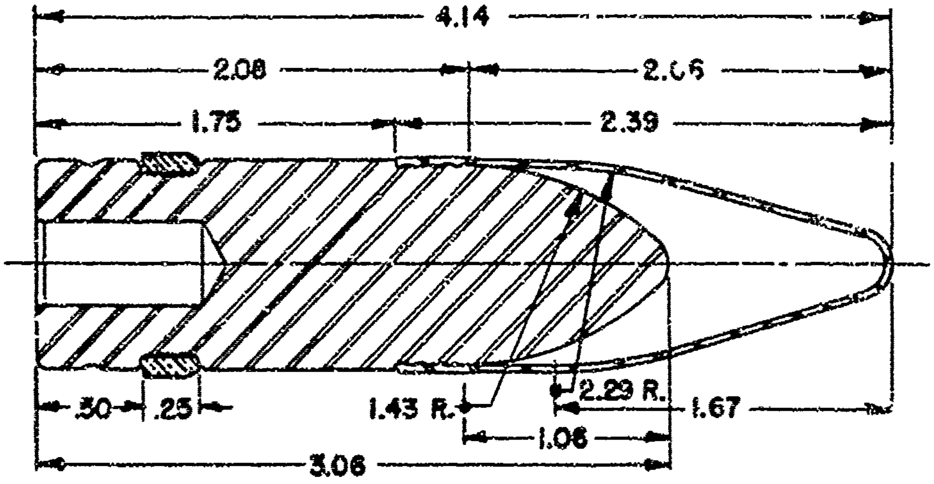
Section		Paragraphs
I	General ----------------------	1
II	Description ------------------	2 - 4
III	Interior ballistic data ---------	5
IV	Exterior ballistic data---------	6 - 7
V	Effect data --------------------	8

SECTION I
GENERAL

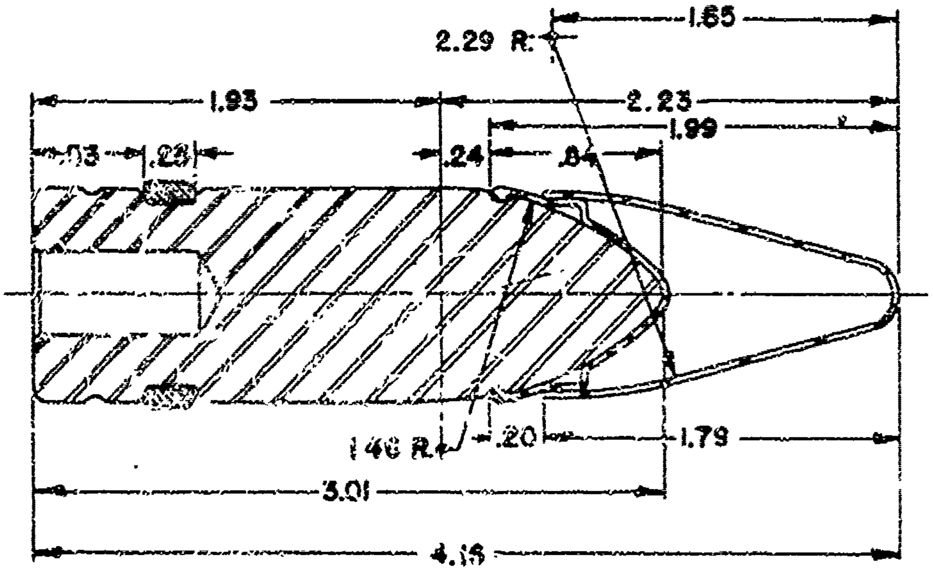
	Paragraph
Purpose -	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 20-mm Armor-piercing Shot M95, which contains a tracer composition. Some data are also given for the experimental Armor-piercing Shot T9E4 with Tracer, which is slightly different from the M95 (T9E5). This information is collected from the drawings, reports, and technical manuals pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS



SHOT, AP, 20-MM, M95



SHOT, AP, 20-MM, T9E4

SECTION II

DESCRIPTION

Paragraph
Drawings - 2
Dimensions - 3
Physical characteristics - 4

2. Drawings.

Shot, AP, M95:	Metal parts assembly	75-2-333
	Metal parts details	75-2-341
Shot, AP, T9E4:	Assembly and details	TAM 130

3. Dimensions. All dimensions below are in calibers.

AP Shot:		M95	T9E4
Band:	Distance from base	0.50	0.53
	Width	0.25	0.25
Body:	Length of cylindrical part	1.75	1.93
	Length of ogival part	1.06	1.08
	Outside length of ogival part	0.00	0.24
	Radius of ogival arc	1.43	1.46
	Total length	3.06	3.01
Windshield assembly:	Length of windshield	2.39	1.79
	Outside length of adapter		0.20
	Length of assembly		1.99
	Length of ogival part	1.97	1.65
	Radius of arc	2.29	2.29
Shot:	Total length	4.14	4.18
	Bearing length	2.08	1.93
	Effective ogival height	2.05	2.23

4. Physical characteristics. The standard weight of the AP Shot M95 with tracer is 2000 grains. The measured physical characteristics of the M95 Shot without tracer and the T9E4 Shot with tracer are as follows:

AP Shot		M95 w/o tr	T9E4 with tr
Weight	lb	1967	2000
Base to center of gravity	cal	1.488	1.474
Axial moment of inertia	$gr.in^2$	148.8	154.5
Transverse moment of inertia	$gr.in^2$	958	957

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore -	5

5. Theoretical yaw in bore. For the AP Shot M95:

Minimum	18 min
Maximum	22 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data -	6
Firing table data- -	7

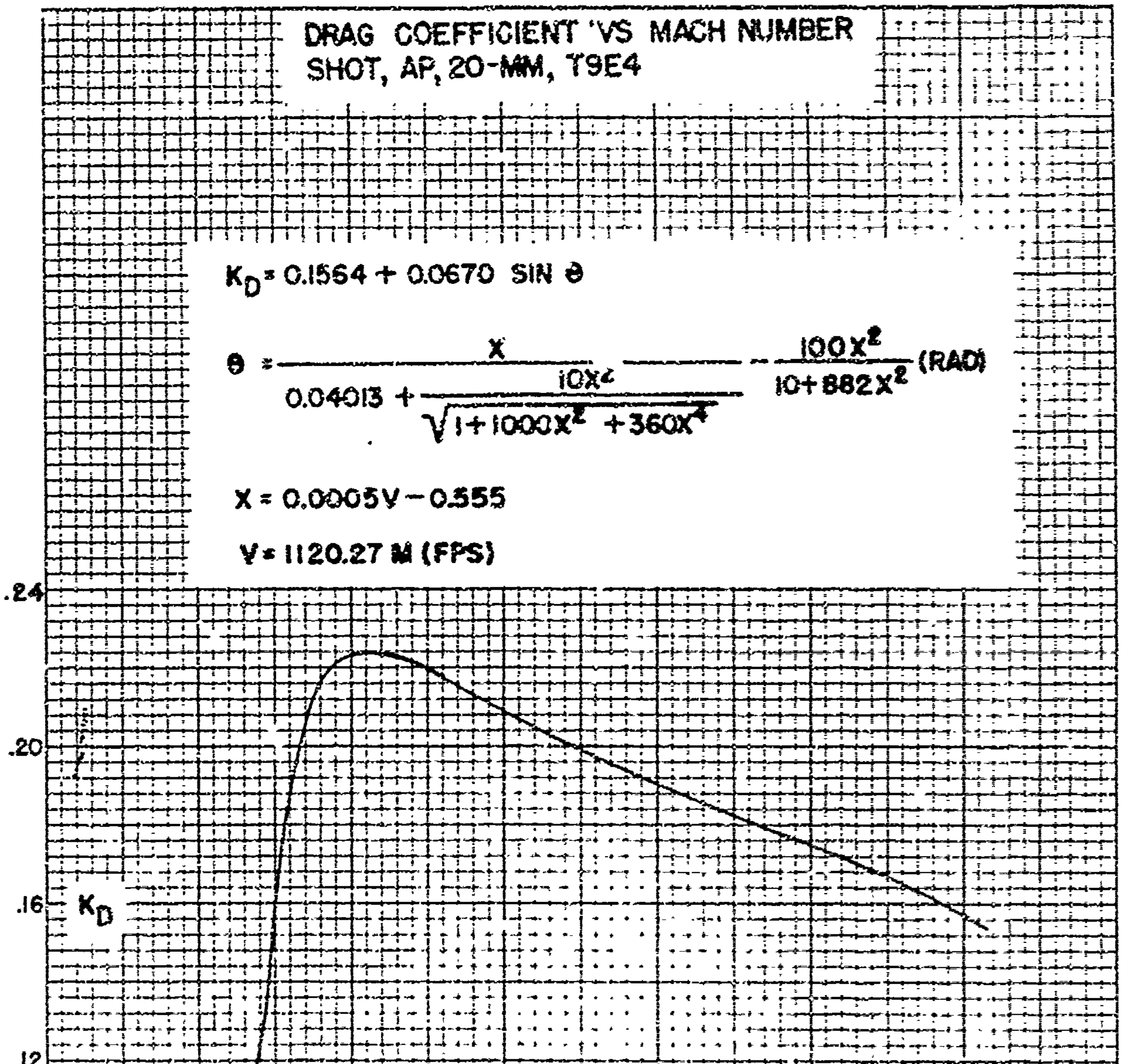
6. Aerodynamic data.

a. Drag. The drag coefficient plotted on page 5 was determined from resistance firings of the AP Shot T9E4 with Tracer at Mach numbers from 0.75 to 2.75. The data listed below were determined from time-of-flight firings of the AP Shot M95 with and without Tracer.

AP Shot M95	With tr	w/o tr
Velocity (fps)	3000	3000
Form factor (Projectile Type 5) i_5	1.12	1.15
Ballistic coefficient (Projectile Type 5) C_5	.413	.401
Drag coefficient K_D	.149	.153

b. Stability. A letter from the director of the Ballistic Research Laboratories to the Chief of Ordnance (APG 472.5/317-1821) gives data on the stability of the AP Shot M95 without Tracer. BRL Report No. [illegible]15, "Aerodynamics of 20-mm Projectiles", gives data on the stability of the AP Shot T9E4 with Tracer.

AP Shot	M95 w/o tr	T9E4 with tr
Velocity (fps)	2700	2750
Moment coefficient K_M	1.68	1.47
Twist of rifling $1/n$	1/25.586	1/25.586
Stability factor s	2.28	2.78



DRAG COEFFICIENT VS MACH NUMBER
SHOT, AP, 20-MM, T9E4

$$K_D = 0.1564 + 0.0670 \sin \theta$$

$$\theta = \frac{X}{0.04013 + \frac{10X^2}{\sqrt{1+1000X^2+360X^4}}} - \frac{100X^2}{10+882X^2} \text{ (RAD)}$$

$$X = 0.0005V - 0.555$$

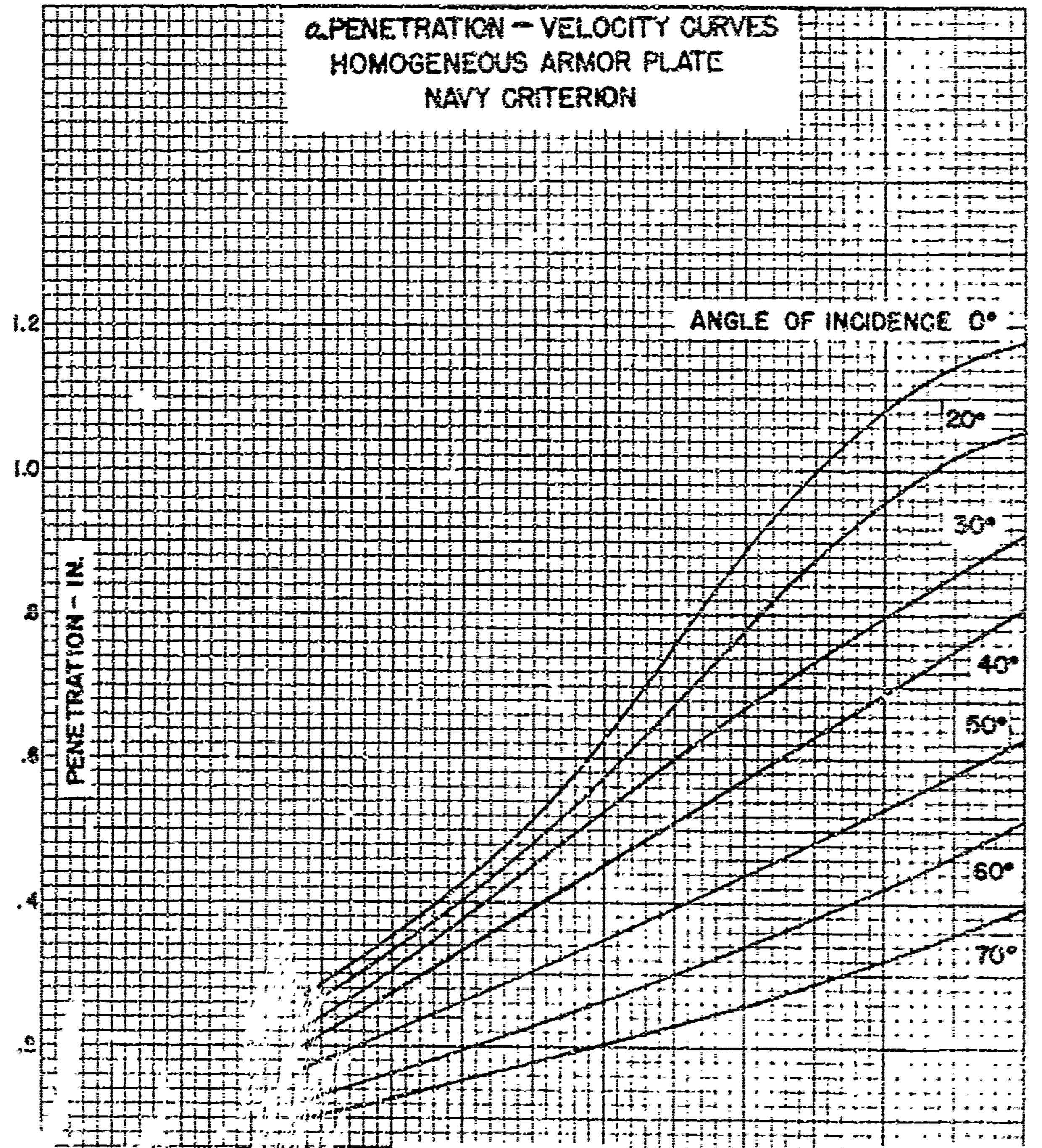
$$V = 1120.27\,M \text{ (FPS)}$$

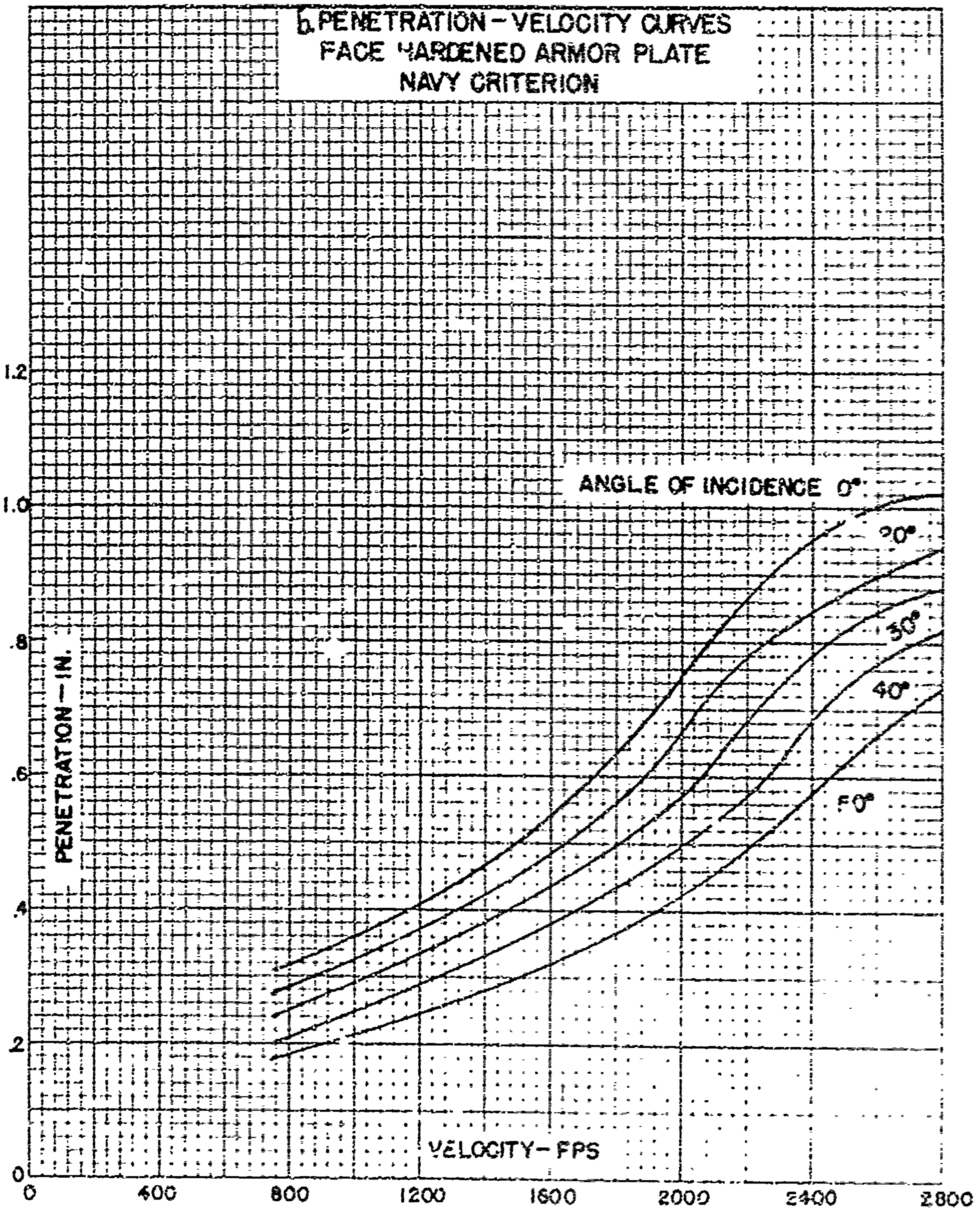
7. Firing table data. No firing tables have been prepared for the AP Shot M95. FT 20AC-J-1, FT 20AC-K-1, FT 20AC-L-1 and FT 20AC-M-1 for 20-mm Automatic Guns M2 and M3 firing HE Shell T23 and HEI Shell M97 give data that are approximately correct for the AP Shot M95 (See [illegible]-1-97). OCM items 26550 and 26906 recommended and approved standardization of the AP Shot M95. Its standard instrumental velocity is 2780 fps at 90 feet from the M2 Gun.

SECTION V
EFFECT DATA

Paragraph
Penetration - 8

8. Penetration. The following graphs, showing the penetration of armor plate by the 20-mm AP Shot M95, were taken from Volume III of "Terminal Ballistic Data".


a. PENETRATION — VELOCITY CURVES
HOMOGENEOUS ARMOR PLATE
NAVY CRITERION
ANGLE OF INCIDENCE 0°
20°
30°
40°
50°
60°
70°
PENETRATION - IN.
1.2
1.0
.8
.6
.4
.2
VELOCITY - FPS
0
400
800
1200
1600
2000
2400
2800


b. PENETRATION – VELOCITY CURVES
FACE HARDENED ARMOR PLATE
NAVY CRITERION
ANGLE OF INCIDENCE 0°
20°
30°
40°
50°
PENETRATION – IN.
1.2
1.0
.8
.6
.4
.2
0
VELOCITY – FPS
0
400
800
1200
1600
2000
2400
2800

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 20-1-96

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
15 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, Incendiary, 20-mm, M96

Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5
IV	Exterior ballistic data	6 - 7

SECTION I
GENERAL

	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics and ballistics of the 20-mm Incendiary Shell M96. This information is collected from the drawings and reports pertaining to this ammunition.

SECTION II
DESCRIPTION

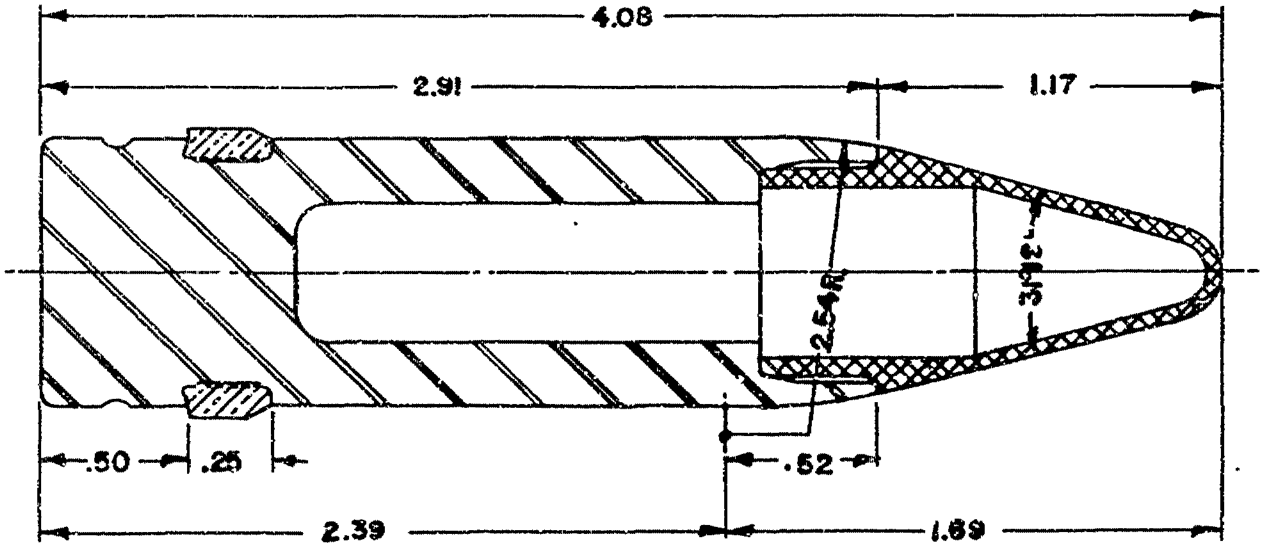
	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. **Drawings.**

Shell: Metal parts assembly	75-2-334
Details	75-2-342

ALL DIMENSIONS IN CALIBERS

I CAL = 0.787"



SHELL, INCENDIARY, 20-MM, M96

3. Dimensions.

Band:	Distance from base	0.50 cal
	Width	0.25 cal
Body:	Length	2.91 cal
	Length of cylindrical part	2.39 cal
	Length of ogival part	0.52 cal
	Radius of ogival arc	2.54 cal
Nose:	Length	1.17 cal
	Conical angle	31°12'
Shell:	Total length	4.08 cal
	Head length	1.69 cal

4. Physical characteristics.

Weight:	Standard	1920 grains
	Measured	1993 grains
Base to center of gravity		1.553 cal
Axial moment of inertia		155.5 gr.in^2
Transverse moment of inertia		1305 gr.in^2

SECTION III

INTERIOR BALLISTIC DATA

Paragraph

Theoretical yaw in bore - 5

5. Theoretical yaw in bore.

Minimum	8 min
Maximum	13 min

SECTION IV

EXTERIOR BALLISTIC DATA

Paragraph

Aerodynamic data - 6
Firing table data- 7

6. Aerodynamic data.

a. Drag. The following values were determined from time-of-flight firings.

Velocity	2800 fps
Projectile weight	1920 gr
Form factor (Projectile Type 5) i_5	1.16
Ballistic coefficient (Projectile Type 5) C_5	.383
Drag coefficient K_D	.156

b. Stability. BRL Report No. 515, "Aerodynamics of 20-mm Projectiles", gives data on the stability of Incendiary Shell M96.

Velocity		2750 fps
Moment coefficient	K_M	1.09
Twist of rifling	$1/n$	1/25.586
Stability factor	s	2.80

7. Firing table data. No firing tables have been prepared for the Incendiary Shell M96. FT 20AC-J-1, FT 20AC-K-1, FT 20AC-L-1 and FT 20AC-M-1 for 20-mm Automatic Guns M2 and M3 firing HE Shell T23 and HEI Shell M97 give data that are approximately correct for the Incendiary Shell M96 (see OH 20-1-97). OCM items 26550 and 26906 recommended and approved standardization of the Incendiary Shell M96. Its standard instrumental velocity is 2810 fps at 90 feet from the M2 Gun.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 20-1-97

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
15 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HEI, 20-mm, M97
with
Fuze, PD, M75

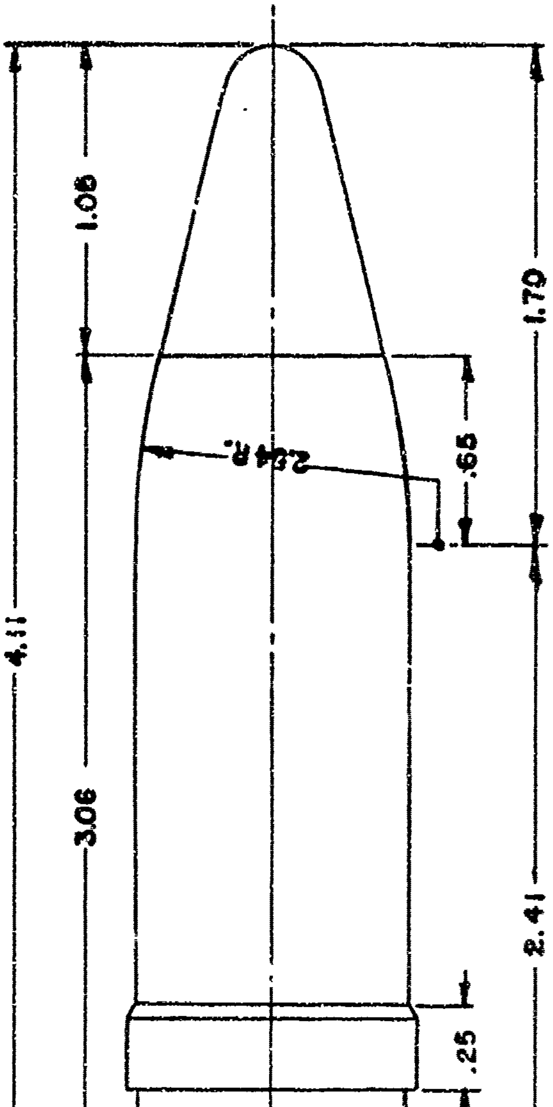
Section		Paragraphs
I	General --------------------	1
II	Description -----------------	2 - 4
III	Interior ballistic data --------	5 - 6
IV	Exterior ballistic data--------	7 - 9
V	Effect data ------------------	10

SECTION I
GENERAL

	Paragraph
Purpose -	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 20-mm High Explosive Incendiary Shell M97 with the Point Detonating Fuze M75. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL. = 0.787"



SHELL, HEI, 20-MM, M97
FUZE, PD, M75

SECTION II

DESCRIPTION

Paragraph
Drawings - 2
Dimensions - 3
Physical characteristics - 4

2. Drawings.

Shell: Metal parts assembly and details	75-2-335
Fuze: Assembly	73-1-193
Details	73-1-194

3. Dimensions.

Band: Distance from base	0.48 cal
Width	0.25 cal
Body: Length of cylindrical part	2.41 cal
Length of ogival part	0.65 cal
Radius of ogival arc	2.54 cal
Fuze: Outside length	1.05 cal
Conical angle	30°24'
Length: Shell	3.06 cal
Shell and fuze	4.11 cal
Ogive and fuze	1.70 cal

4. Physical characteristics.

a. The physical characteristics of the HE Shell T23 with the PD Fuze T71E4, of which the present projectile is a slight modification, are as follows:

Weight	2000 grains
Base to center of gravity	1.643 cal
Axial moment of inertia	165.6 $gr.in^2$
Transverse moment of inertia	1442 $gr.in^2$

b. The standard weight of the HEI Shell M97 with the PD Fuze M75 was changed by OCM item 26550 to 2039 grains.

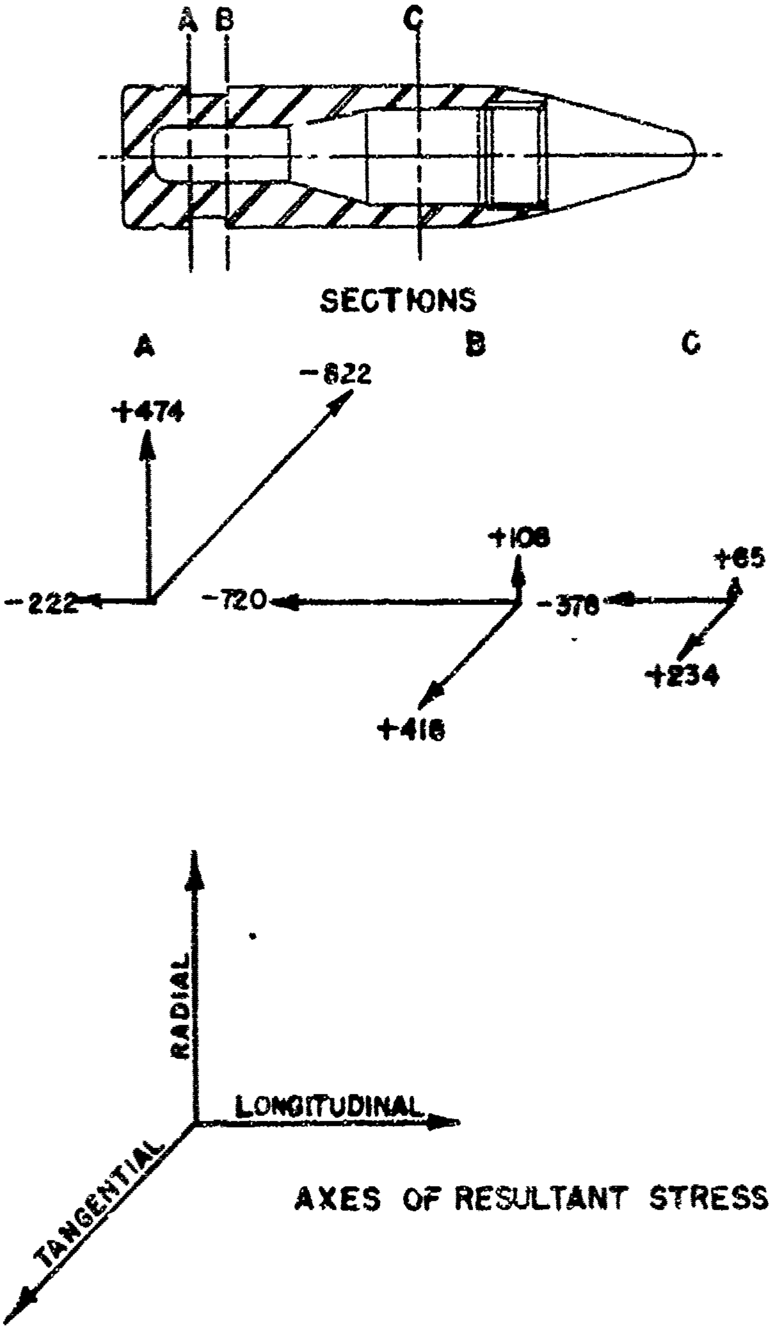


DIAGRAM OF RESULTANT STRESSES

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses -	5
Theoretical yaw in bore -	6

5. **Stresses.** The following table and the graphical representation on page 4 show the longitudinal, radial and tangential stress at each of three sections: (A) the rear corner of the band seat, (B) the front of the band seat, and (C) immediately behind the bourrelet.

Gun, Automatic, 20-mm	M2
Twist of rifling	1/25.586
Cross-sectional area of bore	0.5146 sq in.
Rated maximum pressure	48,000 psi
Total weight of projectile	0.2913 lb (2039 gr)
Muzzle velocity	2800 fps
Density of filler (Incend tetryl)	0.0505 lb per cu in.

Resultant Stress* 100 psi	Section A	Section B	Section C
Longitudinal	-222	-720	-378
Radial	+474	+108	+ 65
Tangential	-822	+418	+234

* + denotes tension, - denotes compression.

6. **Theoretical yaw in bore.**

Minimum	8 min
Maximum	13 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data -	7
Firing table data: Automatic Gun M2 -	8
Firing table data: Automatic Guns M3, M23 and M24 - - - - - - - - - - - - -	9

7. **Aerodynamic data.** The following data, taken from Ballistic Research Laboratory Report No. 515, "Aerodynamics of 20-mm Projectiles", pertain to the HE Shell T23 (Dwg TAM 371) with the PD Fuze T71E4 (Dwg TAM 601):

Velocity	u	2800 fps
Weight	m	2000 gr
Form factor (Projectile Type 5)	i_5	1.14
Ballistic coefficient (Projectile Type 5)	C_5	0.404
Drag coefficient	K_D	0.155
Cross Wind Force coefficient	K_L	1.27
Normal Force coefficient	K_N	1.43
Base to Center of Pressure	h	2.40 cal
Overturning Moment coefficient	K_M	1.09
Ratio of coefficients	K_L/K_M	1.17
Drift function	$Q = K_L/K_M u^2$	1.49×10^{-7}
Yawing Moment coefficient	K_H	1.56
Magnus Moment coefficient	K_T	-0.005
Twist of rifling (7° angle)	$1/n$	1/25.586
Stability factor	s	2.85

8. **Firing table data. Automatic Gun M2** (67.52-inch Tube). FT 20AC-J-1, FT 20AC-K-1 with supplement and FT 20AC-L-1. Twist of rifling: 1/25.586 (7° angle). OCM items 26550 and 26906 recommended and approved standardization of the HEI Shell M97 with the PD Fuze M75. Its standard instrumental velocity is 2780 fps at 90 feet from the M2 Gun. The firing tables were computed for a projectile weight of 2000 grains, which is that of the HE Shell T23 with the PD Fuze T71E4, and a muzzle velocity of 2750 fps.

a. **Form factor.** The form factor of the 2000-grain HE Shell relative to the 20-mm AP Shot T9E4, whose drag coefficient is given in BRLH 20-1-95, is $i = 0.905$.

b. **Ballistic coefficient.** The ballistic coefficient with respect to the drag function of the 20-mm AP Shot T9E4 is $C = 0.510$.

c. **Stability factor** (normal) $s_s = 2.85$

d. **Damping coefficients.** $c' = 0.001,548,8 \text{ ft}^{-1}$
$c'' = 0.000,097,8 \text{ ft}^{-1}$

e. **Windage jump coefficient.** $b = 86,600$ mil. fps

f. **Yaw-drag coefficient.** $K_{D\delta} = 16.4 \text{ rad}^{-2}$

g. **Trajectory data.**

(1) FT 20AC-J-1 gives trajectory data for:

(a) Present range, nearly horizontal flight, and gun flexible in elevation.

(b) Present range, inclined flight, and gun fixed at low elevation.

(2) FT 20AC-K-1 and its supplement give trajectory data for future range, horizontal flight, and all-around fire.

(3) FT 20AC-L-1 gives trajectory data for future range, horizontal and diving flight, and forward fire.

9. **Firing table data. Automatic Guns M3, M23 and M24** (52.50-inch Tube T31).

FT 20AC-K-2. Twist of rifling: 1/25.586 (7° angle). The firing table was computed for a projectile weight of 2000 grains, which is that of the HE Shell T23 with the PD Fuze T71E4, and a muzzle velocity of 2680 fps.

a. **Form factor** (relative to AP Shot T9E4) $i = 0.905$

b. **Ballistic coefficient** (drag function of AP Shot T9E4) $C = 0.510$

c. **Stability factor** (normal) $s_s = 2.85$

d. **Damping coefficients.** $c' = 0.001,548,8 \text{ ft}^{-1}$
$c'' = 0.000,099,2 \text{ ft}^{-1}$

e. **Windage jump coefficient.** $b = 104,311$ mil. fps

f. **Yaw-drag coefficient.** $K_{D\delta} = 16.4 \text{ rad}^{-2}$

g. **Trajectory data.** FT 20AC-K-2 gives trajectory data for future range, horizontal flight and all-around fire.

SECTION V

EFFECT DATA

Paragraph
Fragmentation - 10

10. Fragmentation. The following table, taken from Volume III of "Terminal Ballistic Data", gives the casualties due to fragmentation of the HEI Shell M97. The initial fragment velocity is 1960 fps.

TABLE 37

CASUALTIES

Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (fps)
r	N	B	m	v
10	30	0.0239	0.024	1570
20	21	0.0042	0.033	1340
30	15	0.0013	0.042	1190
40	11	0.0005	0.050	1090
50	10	0.0003	0.057	1020
60	9	0.0002	0.063	972
70	8	0.0001	0.069	929
80	7	0.0001	0.075	891

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 37-1-51

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
17 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shot, APC, 37-mm, M51
with
Self-destroying Tracer

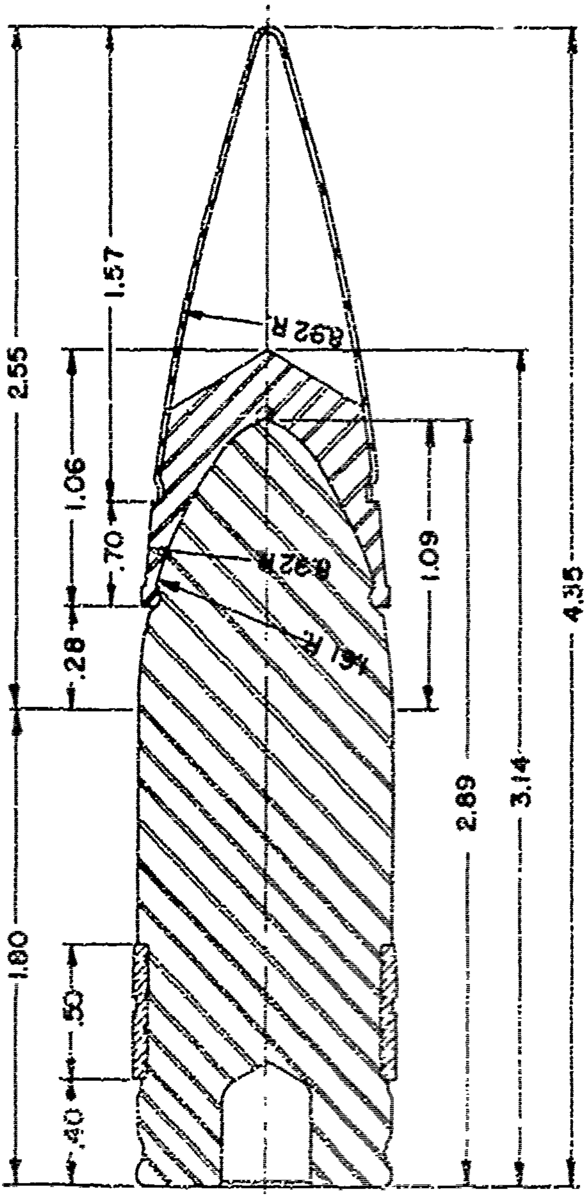
Section		Paragraphs
I	General --------------------	1
II	Description -----------------	2 - 4
III	Interior ballistic data --------	5
IV	Exterior ballistic data--------	6 - 7
V	Effect data ------------------	8

SECTION I
GENERAL

	Paragraph
Purpose -	1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 37-mm Armor-piercing Capped Shot M51, which contains a self-destroying tracer composition. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 1.457"



SHOT, APC, 37-MM, M51

SECTION II

DESCRIPTION

Paragraph
Drawing - 2
Dimensions - 3
Physical characteristics - 4

2. Drawing.

Shot: Metal parts assembly and details	75-2-276

3. Dimensions.

Band:	Distance from base	0.40 cal
	Width	0.50 cal
Cylindrical part of body:	Length	1.30 cal
Ogival part of body:	Length	1.09 cal
	Outside length	0.28 cal
	Radius of arc	1.51 cal
Cap:	Length	1.08 cal
	Outside length	0.70 cal
	Radius of arc	6.92 cal
Windshield:	Length	1.57 cal
	Radius of arc	8.92 cal
Length:	Shot body	2.39 cal
	Shot body and cap	3.14 cal
	Total shot	4.35 cal
	Total ogive	2.55 cal

4. Physical characteristics. These data apply to the shot with unburned tracer composition.

Mean weight (standard)	1.92 lb
Base to center of gravity	1.463 cal
Axial moment of inertia	0.4813 $lb.in^2$
Transverse moment of inertia	3.088 $lb.in^2$

SECTION III

INTERIOR BALLISTIC DATA

Paragraph

Theoretical yaw in bore - 5

5. Theoretical yaw in bore.

Minimum	13 min
Maximum	22 min

SECTION IV

EXTERIOR BALLISTIC DATA

Paragraph

Aerodynamic data - 6
Firing table data - 7

6. Aerodynamic data.

a. Drag. These data were obtained from time-of-flight firings.

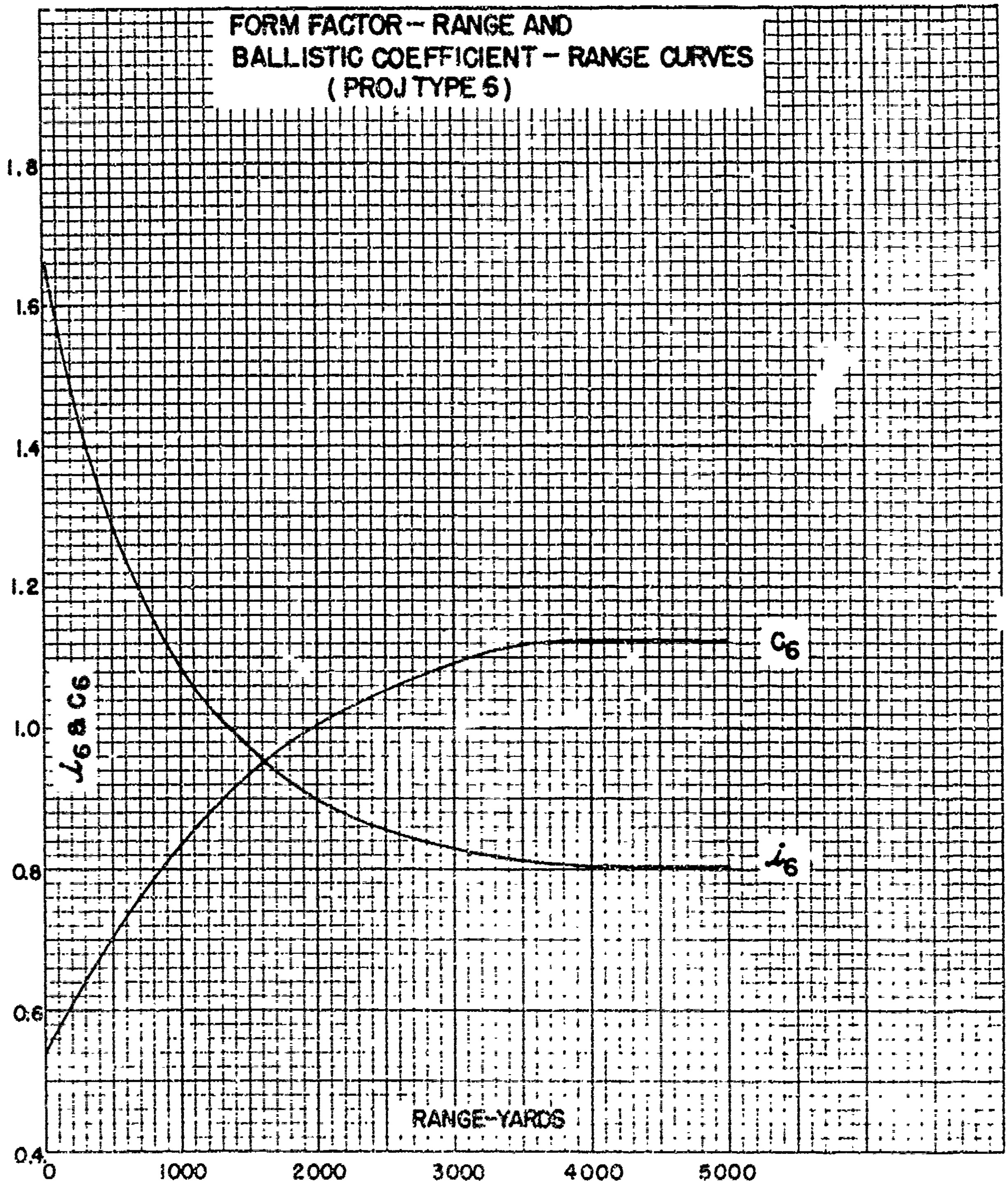
Muzzle velocity	2900 fps
Drag function	G_6
Ballistic coefficient	0.984
Form factor	0.92
Drag coefficient, K_D	0.101

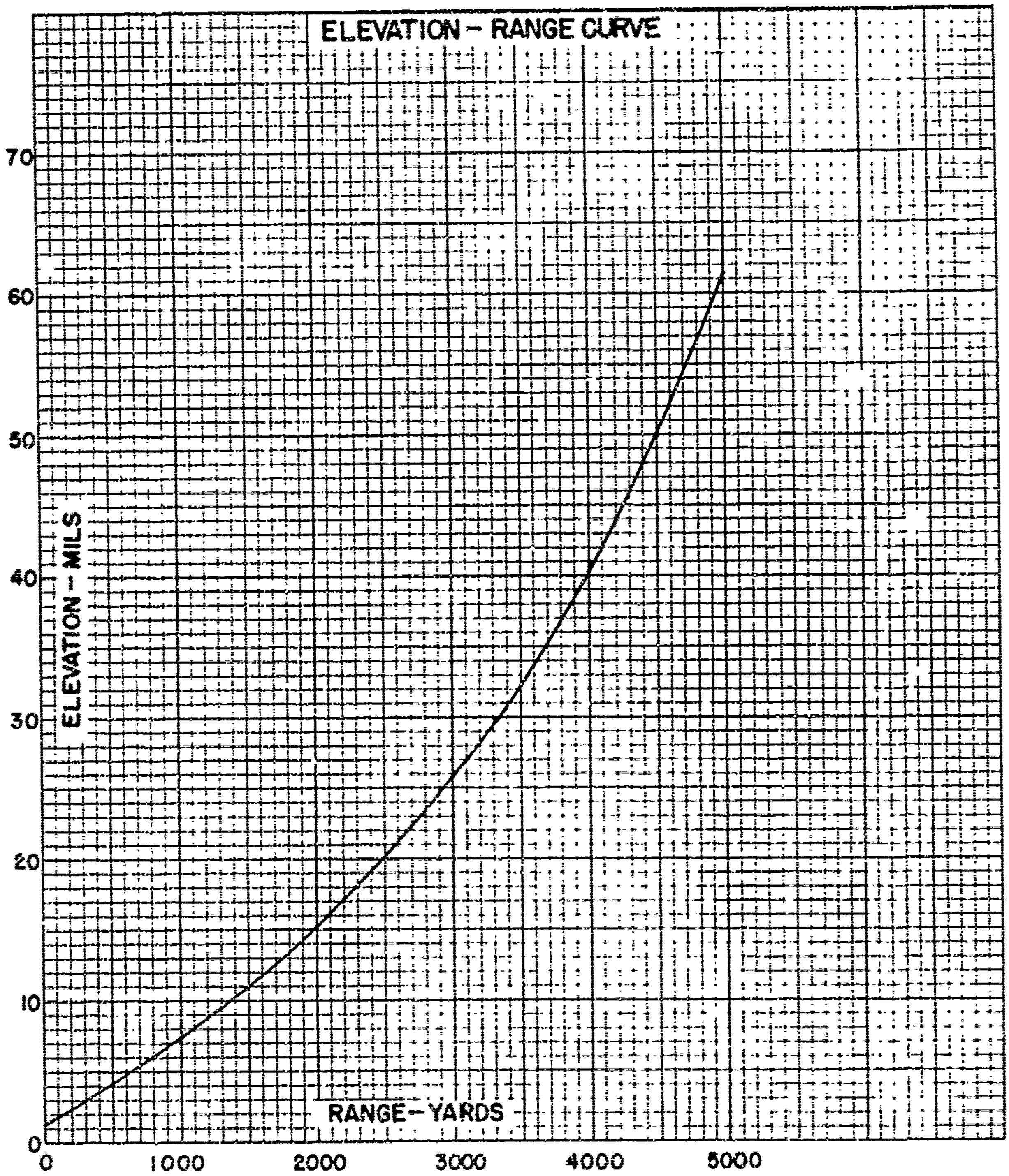
b. Stability. Ballistic Research Laboratory Report No. 225, "Stability of 37-mm HE Shell M63, AP Shot M51, and Proof Projectile M52", gives the stability factors which were determined for this projectile at muzzle velocities of 2740 fps and 1350 fps. It was fired from the Sub-caliber Tube M1925 whose twist of rifling is 1/40. The Tank Gun M6 is rifled with a twist of 1/25.

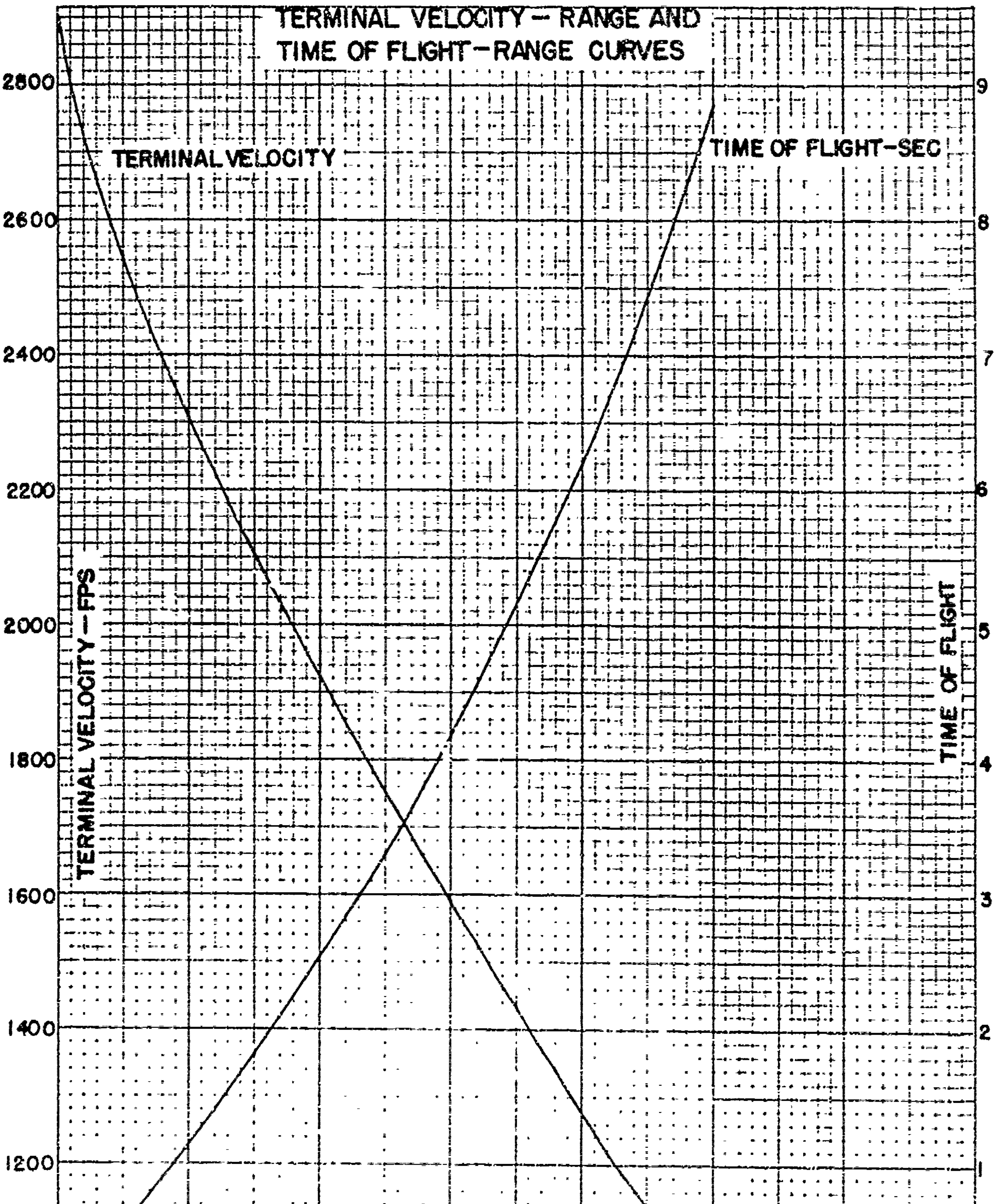
MV fps	Twist of Rifling	Stability Factor	Moment Coef. K_M
1350	1/40	1.23	
2740	1/40	1.18	
Avg	1/40	1.205	1.35 (computed from the moments of inertia of shot with unburnt tracer composition and the observed stability factor)
	1/25	3.1	

7. Firing table data. FT 37-S-3.

Gun, 37-mm, M6 (mounted in Light Tanks M3A3 and M5A1, by applying suitable corrections to the elevation, the firing table may be used for Light Tanks M3A1 and M5 and the Light Armored Car M8). Twist of Rifling: 1/25. Muzzle Velocity: 2900 fps. Projectile weight: 1.92 lb. OCM items 14801 and 14859 recommended and approved standardization of the AP Shot M51. Item 17699 changed its designation to APC Shot M51.


FORM FACTOR – RANGE AND
BALLISTIC COEFFICIENT – RANGE CURVES
(PROJ TYPE 6)
i_6 & C_6
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
C_6
i_6
RANGE-YARDS
0
1000
2000
3000
4000
5000


ELEVATION – RANGE CURVE
ELEVATION – MILS
RANGE – YARDS
0
10
20
30
40
50
60
70
0
1000
2000
3000
4000
5000


TERMINAL VELOCITY – RANGE AND
TIME OF FLIGHT–RANGE CURVES
TERMINAL VELOCITY
TIME OF FLIGHT–SEC
TERMINAL VELOCITY – FPS
TIME OF FLIGHT
RANGE – YARDS
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
0
1000
2000
3000
4000
5000
9
8
7
6
5
4
3
2
1
0

SECTION V

EFFECT DATA

Paragraph
Penetration - 8

8. **Penetration.**

a. **Ballistic Limits. Homogeneous armor plate.**

Plate			Ballistic Limit		Number in Average
Thickness inches	Brinnell Harness	Obliquity deg	Type	fps	
1.00	291	0	Army	1257	3
	286	20		1345	1
	289	30		1396	2
	371	0		1034	4
	374	20		1160	5
	364	30		1518	2
	402	0		986	2
	402	20		1141	3
	402	30		1463	2
1.125	306	0		1410	2
1.18	277	0		1383	11
1.25	248	0		1453	1
	273	0		1388	9
	307	0		1333	4
1.50	233	0		1590	13
	269	0		1614	53
	320	0		1639	8
	360	0		1572	2
	360	20		1724	2
1.75	273	0		1775	1
	274	20		1744	5
2.00	242	0		1860	2
	242	20		2036	2
	274	0		2005	14
	269	20		2062	1
	317	0		1990	8
	325	20		2182	4
2.50	324	0		2308	2
0.625	363	0	Navy	1231	1
0.875	392	0		1943	2
	417	0		1921	2
1.00	---	20		1544	1
	---	46.33		1986	1
1.50	276	0		1563	25
	318	0		1645	7
1.75	---	0		1682	1
2.00	---	0		1748	7

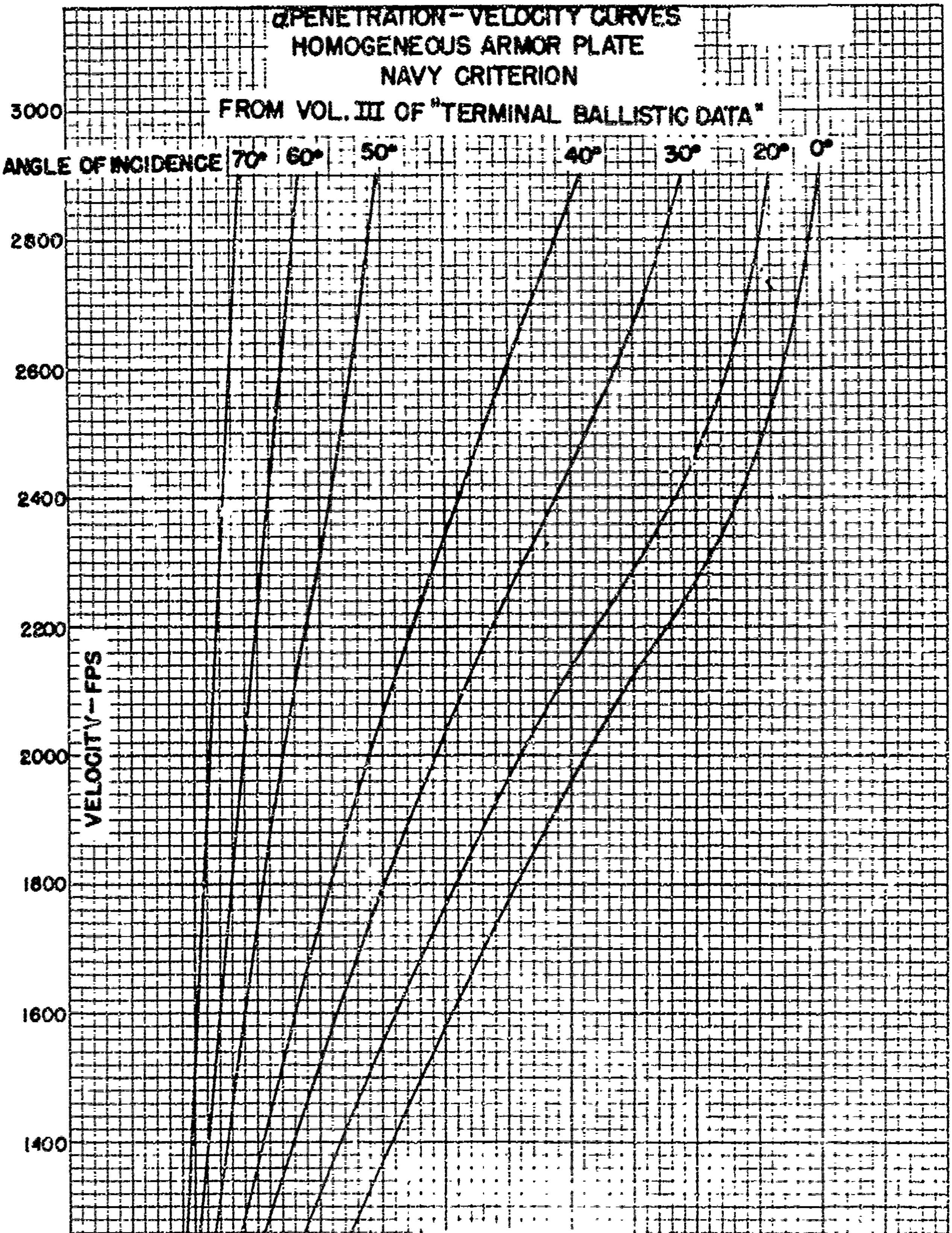
b. **Ballistic Limits. Face-hardened armor plate.**

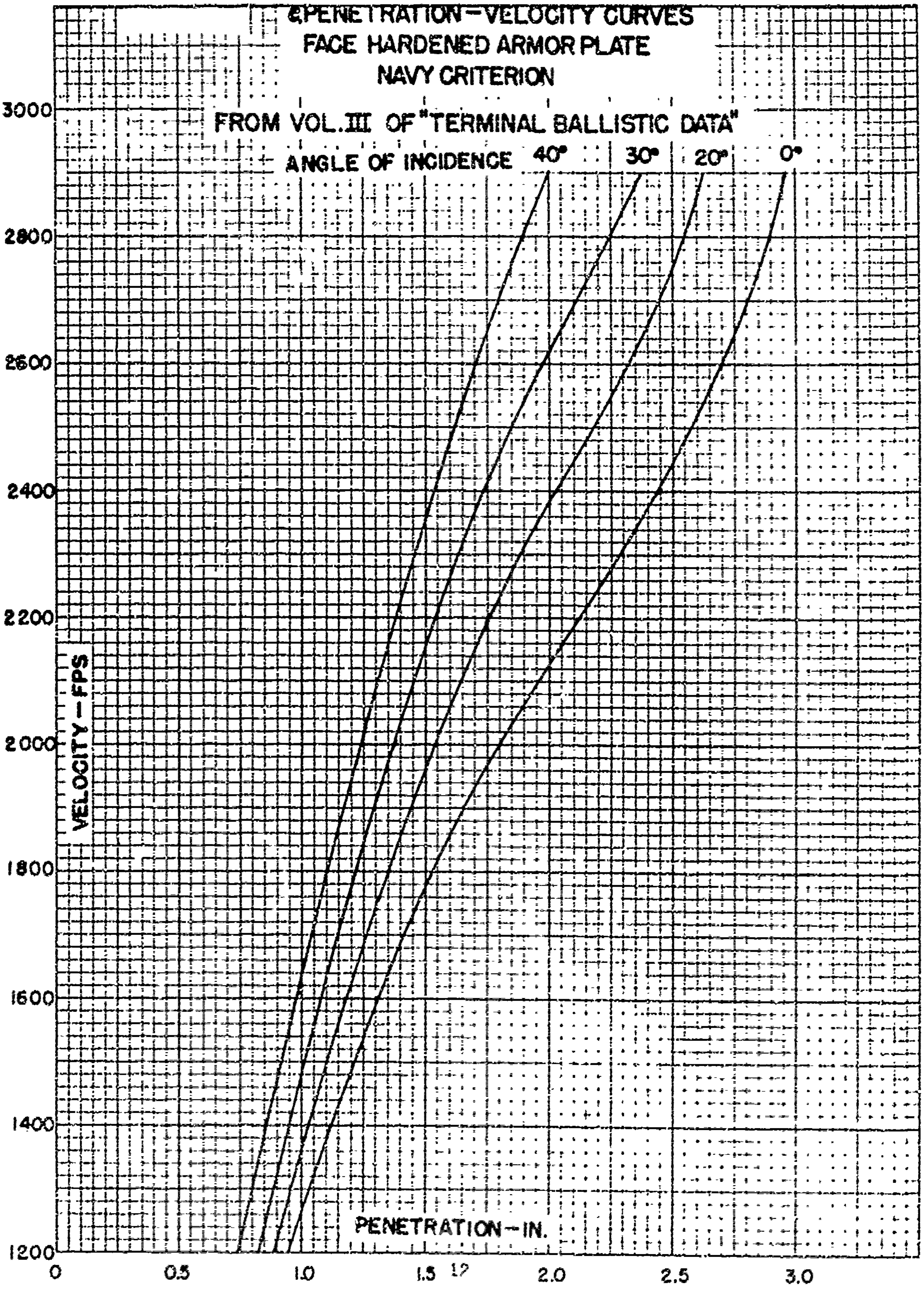
Plate		Ballistic Limit		Number in Average
Thickness inches	Obliquity deg	Type	fps	
0.75	0	Army	1449	14
	25		1038	4
1.00	0		1023	11
	20		1148	4
	30		1298	7
	40		1539	6
1.50	0		1656	30
	20		2011	12
0.50	0	Navy	1003	3
0.625	0		1460	1
1.00	0		1384	8
	20		1298	5
	29		1490	1
	30		1394	5
	40		1549	3
	46.43		1831	1
1.50	0		1871	11
	20		1991	14
	30		2057	8

c. **Vulnerability of German tanks.** The following data on vulnerability of German tanks (Panzerkampfwagen) to APC Shot M51, fired from the 37-mm Tank Gun M6 at a muzzle velocity of 2900 fps, were taken from TM 9-1907, "Ballistic Data, Performance of Ammunition".

Maximum Vulnerable Range - Yards

Tank Model		III		IV		VI
Attack	Angle - deg	0	25	0	25	0
Frontal	Turret Sides	2590	950	2590	950	110
	Turret Front	1200	---	1170	---	---
Flank	Turret Rear	2970	1500	2970	1340	110
	Turret Sides	2590	950	2590	950	110
	Turret Front	1200	---	1170	---	---
	Upper Hull Sides	3200	1730	3200	1730	110
	Lower Hull Sides	3200	1730	3200	1730	870
Rear	Turret Rear	2970	1500	2970	1340	110
	Turret Sides	2590	950	1170	950	110
	Turret Front	1200	---	1170	---	---
	Upper Hull Rear	1460	---	3800	3940	10
	Lower Hull Rear	1580	---	3800	3940	10


α PENETRATION – VELOCITY CURVES
HOMOGENEOUS ARMOR PLATE
NAVY CRITERION
FROM VOL. III OF "TERMINAL BALLISTIC DATA"
ANGLE OF INCIDENCE
70°
60°
50°
40°
30°
20°
0°
VELOCITY – FPS
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
PENETRATION – IN.
0
0.5
1.0
1.5
2.0
2.5
3.0


PENETRATION—VELOCITY CURVES
FACE HARDENED ARMOR PLATE
NAVY CRITERION
FROM VOL. III OF "TERMINAL BALLISTIC DATA"
ANGLE OF INCIDENCE
40°
30°
20°
0°
VELOCITY — FPS
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
PENETRATION — IN.
0
0.5
1.0
1.5
2.0
2.5
3.0

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 37-1-54

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
18 February 1949

# BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 37-mm, M54
with
Shell-destroying Tracer
and
Fuze, PD, M56

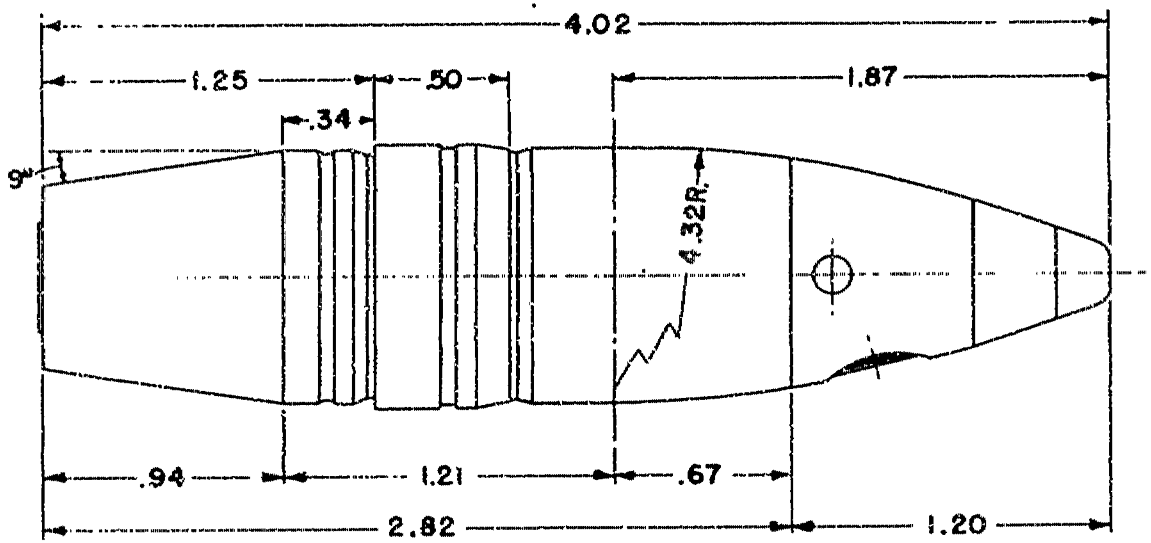
Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 10
V	Effect data	11

SECTION I
GENERAL

	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 37-mm High Explosive Shell M54 with Shell-destroying Tracer and the Point Detonating Fuze M56. This information is collected from the drawings, reports and firing tables pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 1.457"



SHELL, HE, 37-MM, M54
FUZE, PD, M56

SECTION II

DESCRIPTION

Paragraph
Drawings - 2
Dimensions - 3
Physical characteristics - 4

2. Drawings.

Shell: Metal parts assembly and details	75-2-279
Loading assembly and details	75-14-225
Fuze: Assembly	73-2-158
Details	73-2-159, 160, 161

3. Dimensions.

Boattail: Angle	9°00'
Length	0.94 cal
Band: Distance from boattail	0.34 cal
Distance from base	1.25 cal
Width	0.50 cal
Cylindrical body: Length	1.21 cal
Ogive: Length	0.67 cal
Radius of arc	4.32 cal
Fuze: Outside length	1.20 cal
Length: Shell	2.82 cal
Shell and fuze	4.02 cal
Ogive and fuze	1.87 cal

4. Physical characteristics.

Mean weight (standard)	1.34 lb
Base to center of gravity	1.536 cal
Axial moment of inertia*	0.3724 lb.in^2
Transverse moment of inertia*	2.470 lb.in^2

*Measured with the HE Shell T12 and aluminum Dummy Fuze T30. The HE Shell M54 is a slight modification of the HE Shell T12. The PD Fuze M56 has the same contour as the Dummy Fuze T30 except for a screw with a flat head about 0.6 inch in diameter that is countersunk in the M56 Fuze.

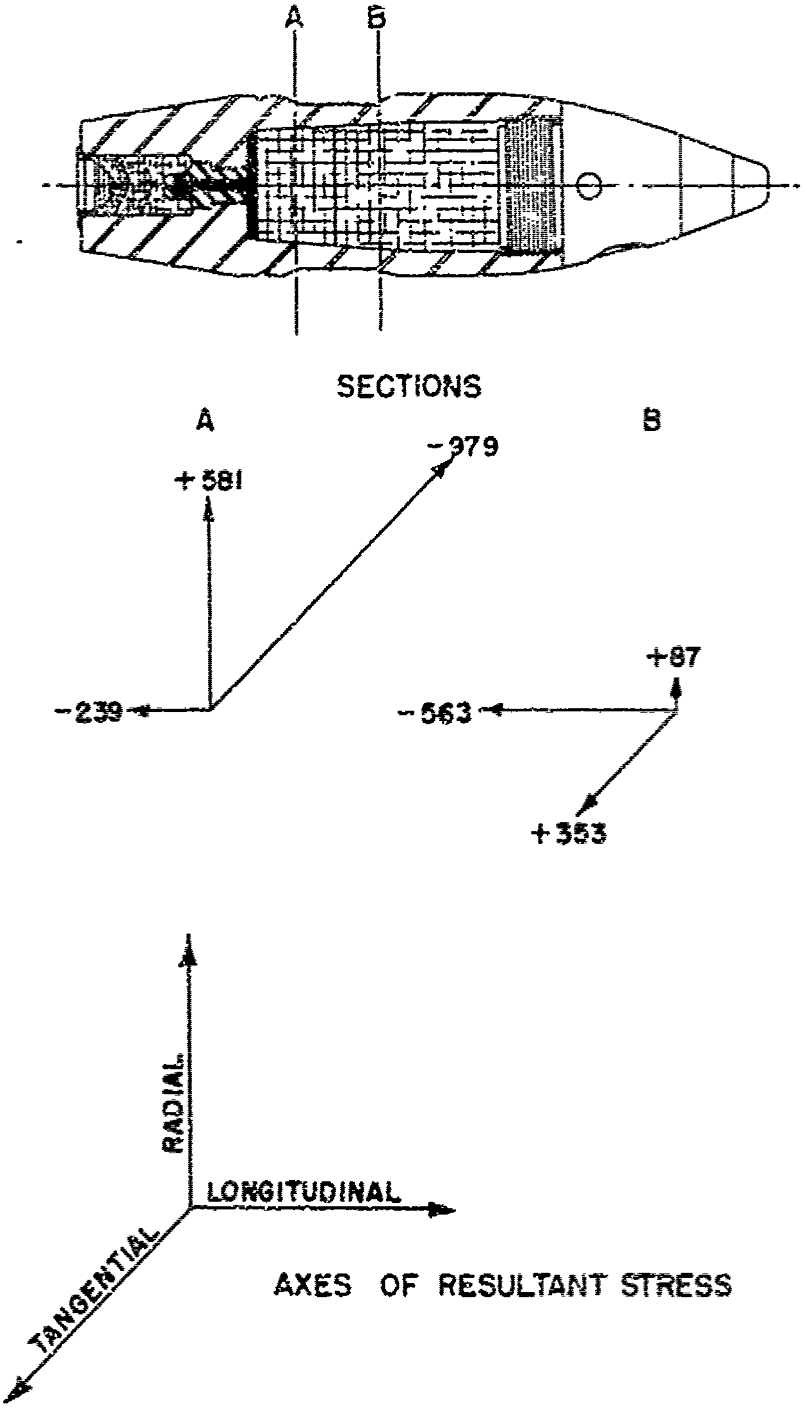


DIAGRAM OF RESULTANT STRESSES

SECTION III

INTERIOR BALLISTIC DATA

Paragraph
Stresses - 5
Theoretical yaw in bore - 6

5. Stresses. The following table and the graphical representation on page 4 show the longitudinal, radial and tangential stress at each of two sections. (A) the rear corner of the band seat and (B) the front of the band seat.

Gun, Automatic (antiaircraft), 37-mm	M1A2
Twist of rifling	1/30
Cross-sectional area of bore	1.722 sq in.
R ed maximum pressure	30,000 psi
Total weight of projectile	1.34 lb
Muzzle velocity	2600 fps
Density of filler (tetryl)	0.0488 lb per cu in.

Resultant Stress* 100 psi	Section A	Section B
Longitudinal	-239	-563
Radial	+581	- 57
Tangential	-979	+353

* + denotes tension, - denotes compression.

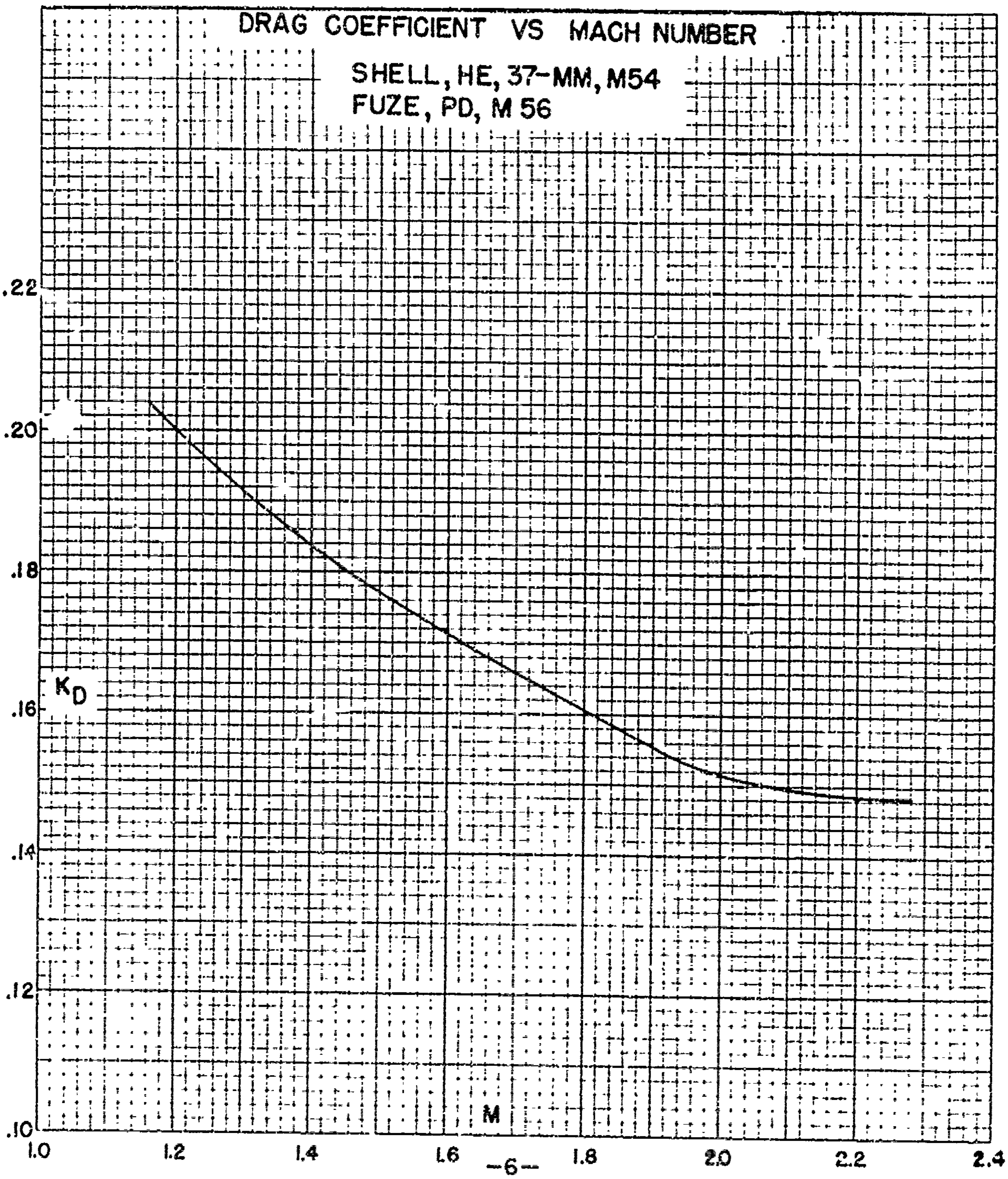
6. Theoretical yaw in bore.

Minimum	6 min
Maximum	18 min

SECTION IV

EXTERIOR BALLISTIC DATA

Paragraph
Aerodynamic data - 7
Firing table data: Automatic Gun M1A2 - - - - - - - - - - - - - - - - - - - 8
Firing table data: Automatic Guns M4 and M10 - - - - - - - - - - - - - - - - 9
Firing table data. Automatic Gun M9 - 10


DRAG COEFFICIENT VS MACH NUMBER
SHELL, HE, 37-MM, M54
FUZE, PD, M 56
.22
.20
.18
.16
.14
.12
.10
K_D
M
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

7. **Aerodynamic data.** The drag coefficient plotted on page 6 and the aerodynamic data tabulated below were taken from Ballistic Research Laboratory Reports No. 354 and 357, "Aerodynamics of 37-mm HE Shell M54" and "Damping of Calibers 0.30 and 0.50 Bullets and 37-mm HE Shell". The time of flight, drift, and yaw firings were conducted with the HE Shell M54 and the PD Fuze M56 without the detonator.

Velocity	u	2000 fps	
Drag coefficient	K_D	0.161	
Cross Wind Force coefficient	K_L	0.98	
Normal Force coefficient	K_N	1.14	
Base to Center of Pressure	h	3.20 cal	
Overturning Moment coefficient	K_M	1.89	
Ratio of coefficients	K_L/K_M	0.518	
Drift function	$Q = K_L/K_M u^2$	13.0×10^{-8}	
Yawing Moment coefficient	K_H	3.16	
Magnus Moment coefficient	K_J	-0.19	
Twist of Rifling	$1/n$	1/30	1/25
Stability factor	s	1.66	2.39

8. **Firing table data. Automatic Gun M1A2. (Antiaircraft)**

FT 37AA-N-2. Twist of rifling: 1/30. Muzzle velocity: 2500 fps (the standard muzzle velocity for a new gun is 2600 fps). OCM items 15811 and 15866 recommended and approved standardization of the HE Shell M54 and PD Fuze M56 in the Automatic Gun M1A2.

a. **Form factor** (Proj Type 5). $i_5 = 0.92$

b. **Ballistic coefficient** (Proj Type 5). $C_5 = 0.69$

c. **Trajectory data.** Trajectory and time curves for a muzzle velocity of 2500 fps are given on the trajectory chart, which is appended to the firing tables.

Maximum horizontal range	8875 yd
Maximum ordinate	6200 yd

9. Firing table data. Automatic Guns M4 and M10 (Aircraft).

FT 37AC-AO-1 and FT 37AC-AX-1. Twist of rifling: 1/25. Muzzle velocity: 2000 fps. The M10 Gun is a modification of the M4 Gun, with a disintegrating belt feed. OCM items 15811 and 15866 recommended and approved standaridzation of the HE Shell M54 and PD Fuze M56 in the Automatic Gun M4.

a. Form factor. The form factor of the HE Shell M54 with PD Fuze M56 relative to its own drag function is i = 1.00.

b. Ballistic coefficient. The ballistic coefficient of this 1.34-lb projectile relative to its own drag function is C = 0.631. The drag coefficient curve is shown on page 6. The 'drag function' to which FT 37AC-AO-1 refers is G/0.631: the ballistic coefficient relative to this function is 1.00.

c. Stability factor (normal). $s_s = 2.39$

d. Damping coefficients. $c' = 0.001{,}72 \text{ ft}^{-1}$
$c'' = 0.000{,}066 \text{ ft}^{-1}$

e. Windage jump coefficient. $b = 38{,}000$ mil. fps

f. Yaw-drag coefficient. $K_{D\delta} = 16.4 \text{ rad}^{-2}$

g. Trajectory data. FT 37AC-A0-1 gives time of flight and vertical and lateral deflections for all-around fire from a gun mounted in aircraft in horizontal flight. FT 37AC-AX-1 gives similar data for limited fire from a gun mounted in aircraft in horizontal flight, with corrections for a dive angle of 800 mils.

10. Firing table data. Automatic Gun M9 (Aircraft).

FT 37AC-BF-1 and FT 37AC-BL-1. Twist of rifling: 1/30. Muzzle velocity: 2550 fps (the standard muzzle velocity for a new gun is 2600 fps). OCM items 15811 and 15866 recommended and approved standardization of the HE Shell M54 and PD Fuze M56 in aircraft guns.

a. Form factor. The form factor of the HE Shell M54 with PD Fuze M56 relative to its own drag function is i = 1.00.

b. Ballistic coefficient. The ballistic coefficient of this 1.34-lb projectile relative to its own drag function is C = 0.631. The drag coefficient curve is shown on page 6. The 'drag function' to which FT 37AC-BF-1 refers is G/0.631: the ballistic coefficient relative to this function is 1.00.

c. **Stability factor (normal).** $s_s = 1.66$

d. **Damping coefficients.** $c' = 0.001,72 \text{ ft}^{-1}$
$c' = 0.000,066 \text{ ft}^{-1}$

e. **Windage jump coefficient.** $b = 40,375$ mil. fps

f. **Yaw-drag coefficient.** $K_{D\delta} = 16.4 \text{ rad}^{-2}$

g. **Trajectory data.** FT 37AC-BF-1 gives time of flight and vertical and lateral deflections for all-around fire from a gun mounted in aircraft in horizontal flight. FT 37AC-BL-1 gives time of flight, gun elevation, and lateral deflection for forward fire from a gun mounted in aircraft in horizontal flight.

SECTION V

EFFECT DATA

Paragraph
Fragmentation - 11

11. **Fragmentation.** Firing Record P36686 gives the results of a fragmentation test of three HE Shell M54 with a modified PD Fuze M56, conducted at Aberdeen Proving Ground. Two semi-circular panels 6 feet high were made of pine boards with a nominal thickness of 1 inch: panel A had a radius of 10 feet; panel B, 20 feet. Each shell was suspended at the common center of the circular arcs in a plane bisecting the panels with its axis horizontal and directed toward the edges of the panels. The shell were detonated statically. The velocity of some of the fragments was measured at a distance of 10 feet. The number of perforations and penetrations in each board were counted. The following table gives the velocity in each spray and the number of perforations and penetrations in each panel.

Round No.	Velocity - fps			Perforations			Penetrations		
	Side	Nose	Tail	A	B	Total	A	B	Total
1	3160	1460	----	21	11	32	157	63	220
2	2520	----	1900	41	12	53	191	119	310
3	----	730	1330	30	16	46	93	108	201

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 37-1-59

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland
21 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shot, APC, 37-mm, M59
with
Self-destroying Tracer

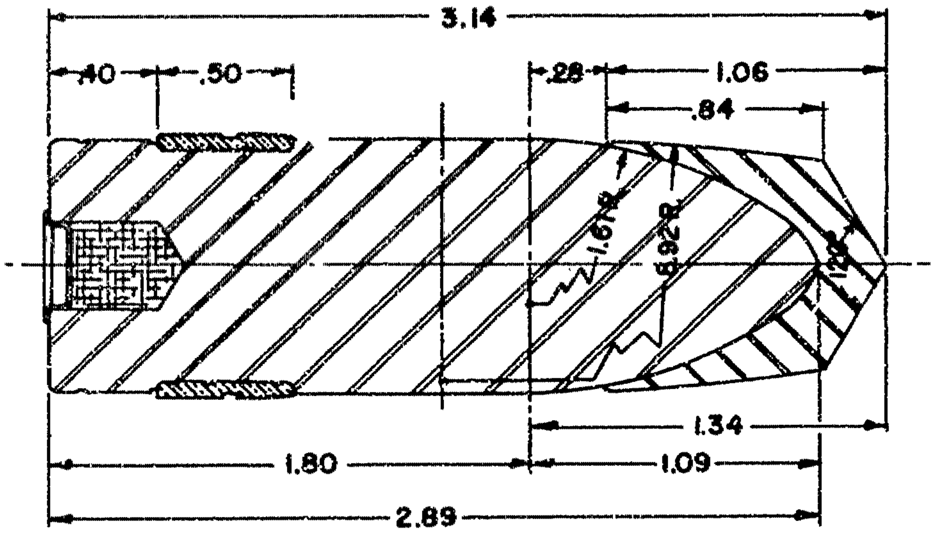
Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5
IV	Exterior ballistic data	6 - 8
V	Effect data	9

SECTION I
GENERAL

	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 37-mm Armor-piercing Capped Shot M59, which contains a self-destroying tracer composition. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 1.457"



SHOT, APC, 37-MM, M59

SECTION II

DESCRIPTION

	Paragraph
Drawing -	2
Dimensions -	3
Physical characteristics -	4

2. Drawing.

Shot: Metal parts assembly and detail	75-2-289

3. Dimensions.

Band: Distance from base	0.40 cal
Width	0.50 cal
Cylindrical part of body: Length	1.80 cal
Ogival part of body: Length	1.09 cal
Outside length	0.28 cal
Radius of arc	1.61 cal
Cap: Length	1.06 cal
Length of ogival part	0.84 cal
Radius of arc	8.92 cal
Vertical angle	120°
Length: Shot body	2.69 cal
Total ogive	1.34 cal
Total projectile	3.14 cal

4. Physical characteristics.

Weight (standard)	1.91 lb
Base to center of gravity	1.450 cal
Axial moment of inertia	0.4685 $lb.in^2$
Transverse moment of inertia	3.015 $lb.in^2$

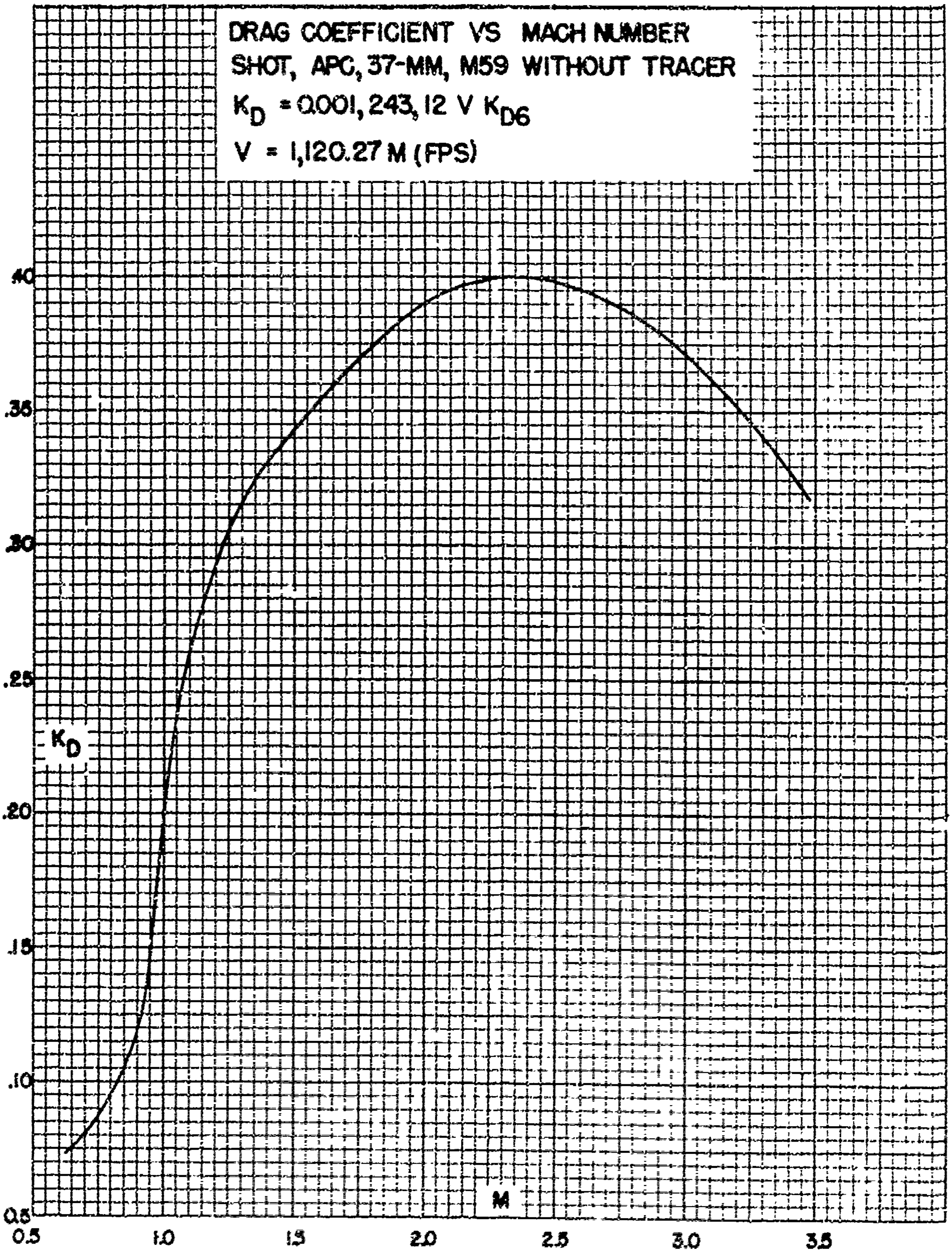
SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore -	5

5. Theoretical yaw in bore.

Minimum	13 min
Maximum	22 min



DRAG COEFFICIENT VS MACH NUMBER
SHOT, APC, 37-MM, M59 WITHOUT TRACER
K_D = 0.001, 243, 12 V K_D6
V = 1,120.27 M (FPS)
.40
.35
.30
.25
K_D
.20
.15
.10
0.5
M
0.5
1.0
1.5
2.0
2.5
3.0
3.5

SECTION IV

EXTERIOR BALLISTIC DATA

Paragraph

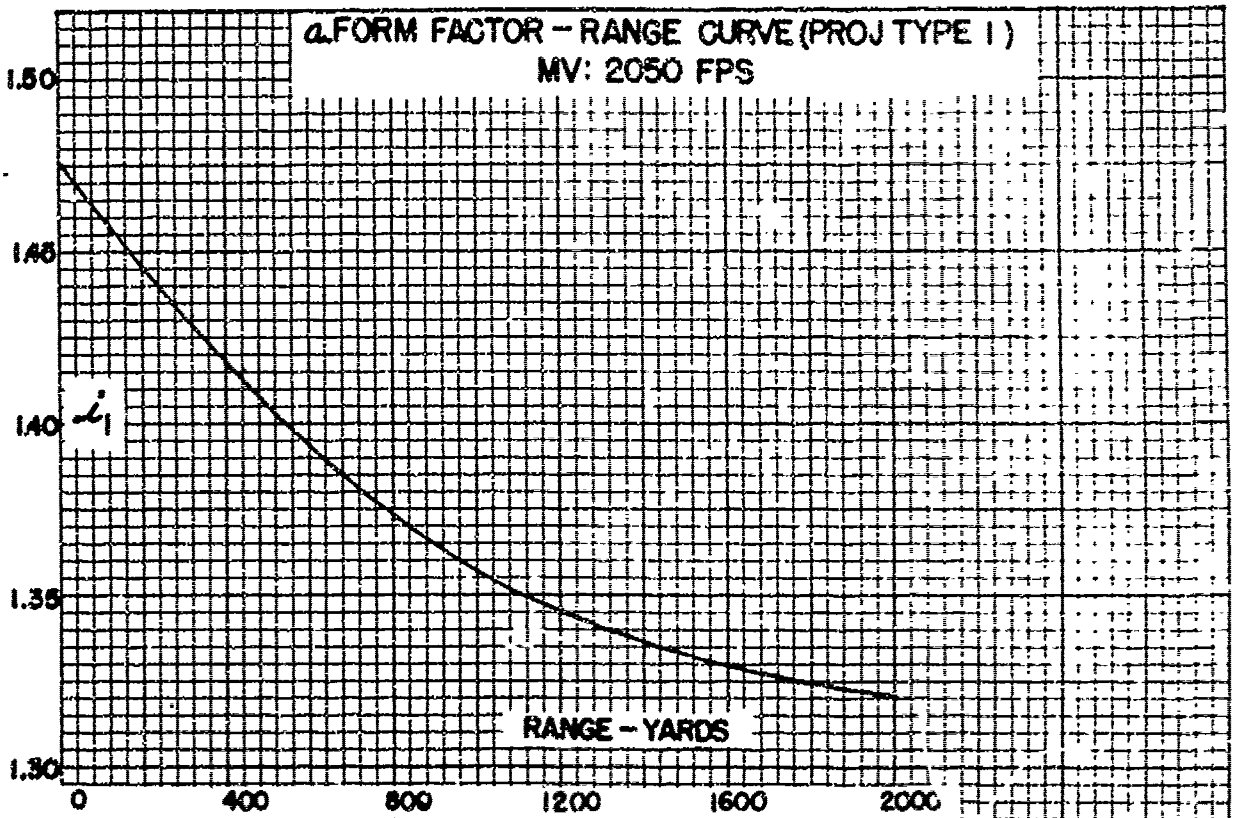
Aerodynamic data - 6
Firing table data: Automatic Gun, M1A2 - 7
Firing table data: Automatic Gun M9 - 8

6. Aerodynamic data. The drag coefficient plotted on page 4 was determined from resistance firings of the APC Shot M59 without tracer at Mach numbers from 1.1 to 2.25. The other data listed below were taken from Ballistic Research Laboratory Report No. 436, "Yaw and Drift of 37-mm Armor-piercing Shots", and pertain to M59 Shot with tracer.

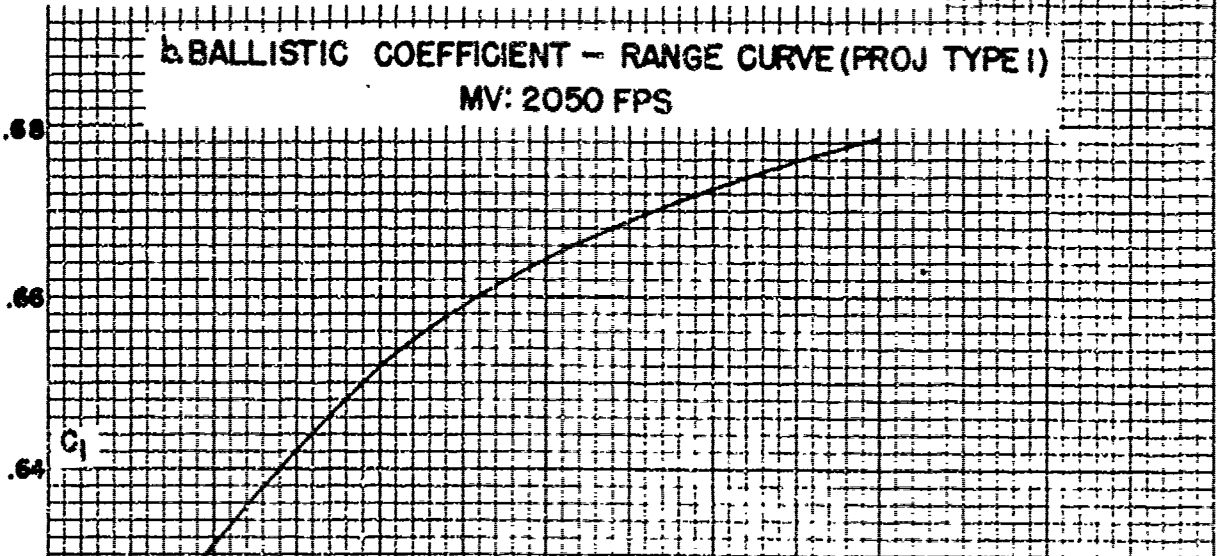
Velocity	u	2800 fps
Drag coefficient	K_D	0.396
Cross Wind Force coefficient	K_L	0.093
Normal Force Coefficient	K_N	0.489
Base to Center of Pressure	h	1.96 cal
Overturning Moment coefficient	K_M	0.250
Ratio of coefficients	K_L/K_M	0.37
Drift function	$Q = K_L/K_M u^2$	4.7×10^{-8}
Yawing Moment coefficient	K_H	1.62
Magnus Moment coefficient	K_J	-0.125
Twist of rifling	$1/n$	1/30
Stability factor	s	12.15

7. Firing table data. Automatic Gun M1A2 (Antiaircraft).

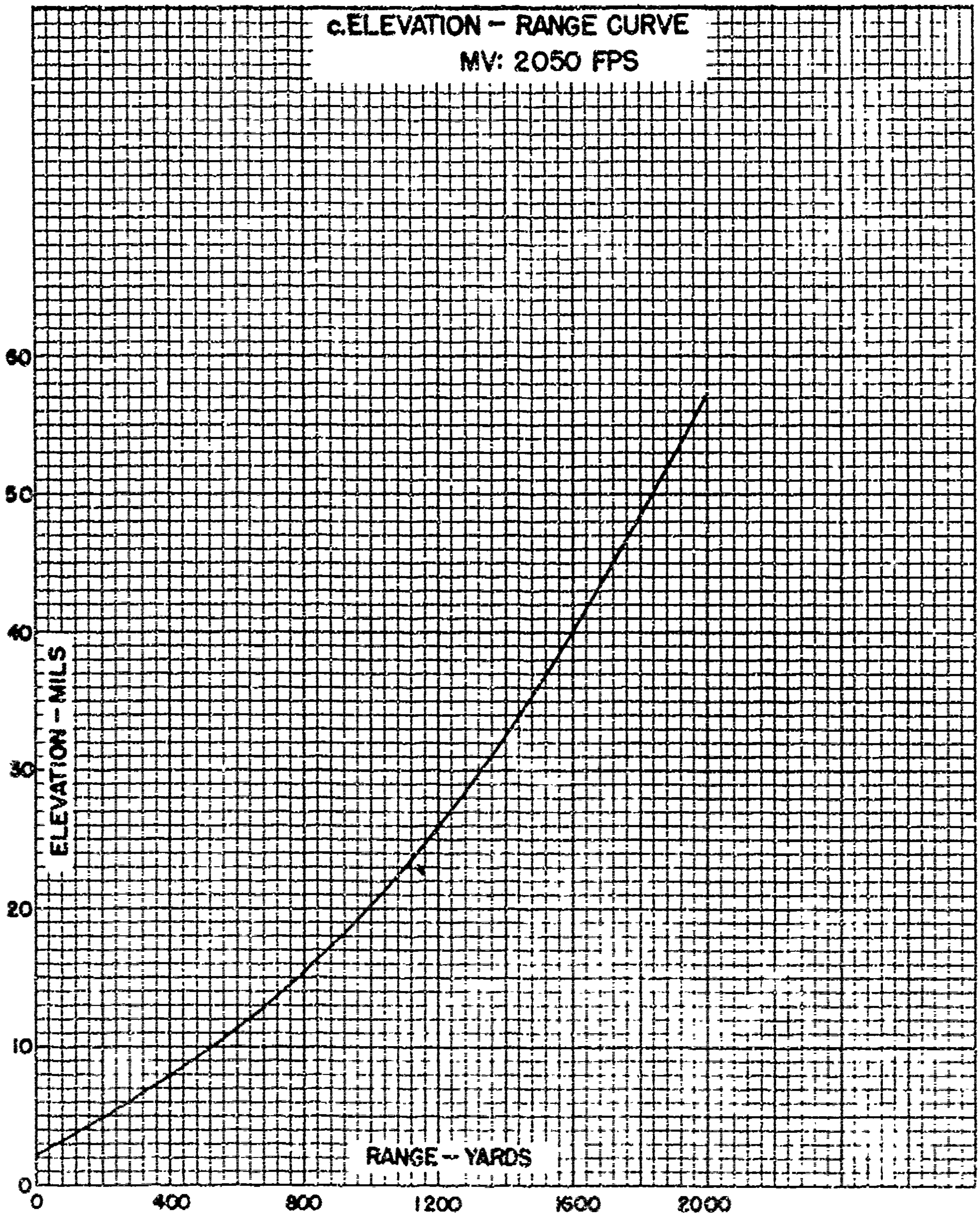
FT 37AA-N-2, C1. Twist of rifling: 1/30. Muzzle velocity: 2050 fps. OCM items 16086 and 16144 recommended and approved standardization of the AP Shot M59 in the Automatic Gun M1A2. OCM item 17699 changed its designation from AP to APC.

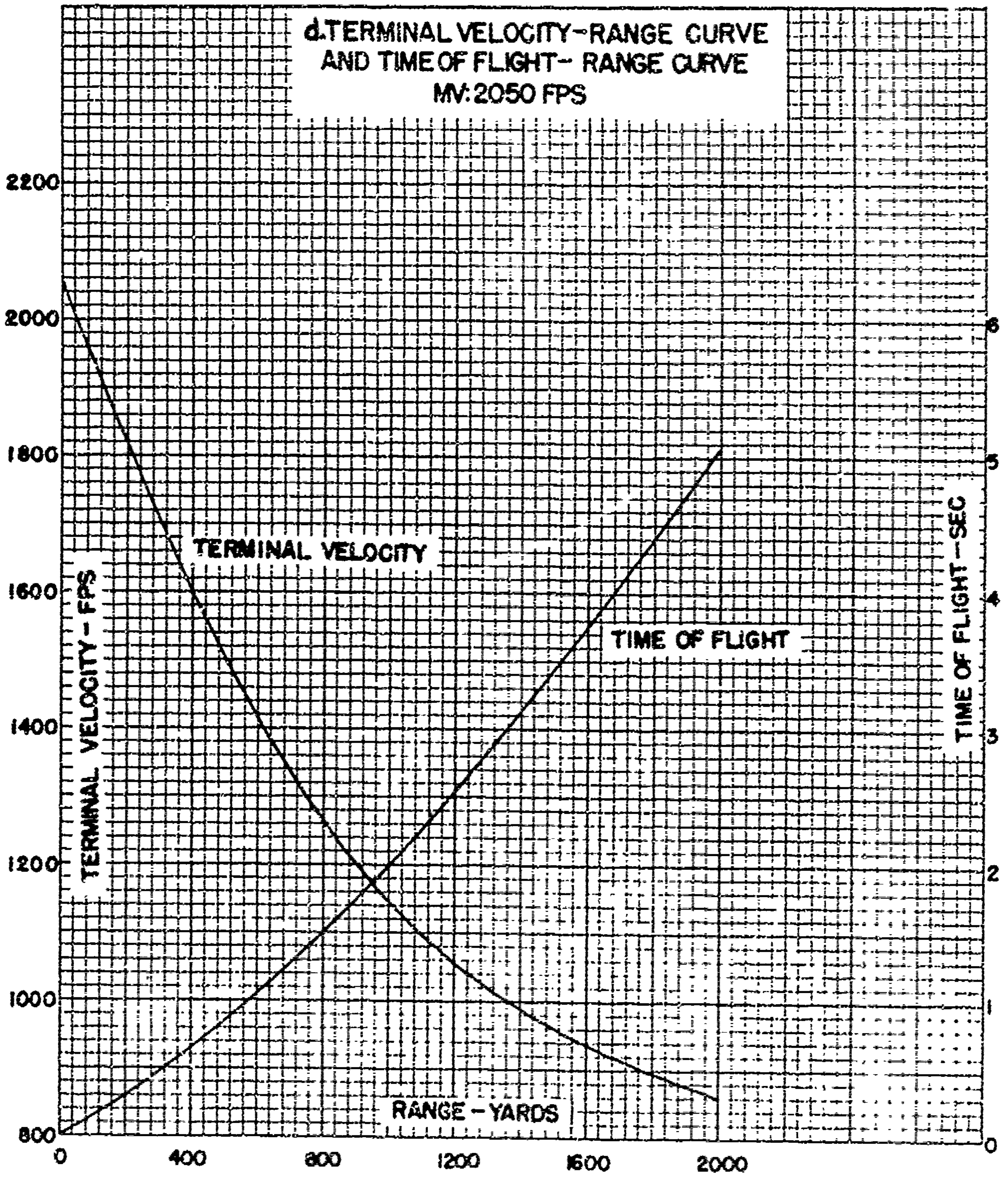


a. FORM FACTOR – RANGE CURVE (PROJ TYPE I)
MV: 2050 FPS



b. BALLISTIC COEFFICIENT – RANGE CURVE (PROJ TYPE I)
MV: 2050 FPS


c.ELEVATION – RANGE CURVE
MV: 2050 FPS
ELEVATION – MILS
0
10
20
30
40
50
60
RANGE – YARDS
0
400
800
1200
1600
2000


d. TERMINAL VELOCITY-RANGE CURVE
AND TIME OF FLIGHT- RANGE CURVE
MV: 2050 FPS
TERMINAL VELOCITY
TIME OF FLIGHT
TERMINAL VELOCITY - FPS
TIME OF FLIGHT - SEC
RANGE - YARDS
2200
2000
1800
1600
1400
1200
1000
800
0
400
800
1200
1600
2000
6
5
4
3
2
1
0

8. Firing table data. Automatic Gun M9 (Aircraft).

FT 37AC-BC-1. Twist of rifling: 1/30. Muzzle velocity: 2800 fps. OCM items 20955 and 21241 recommended and approved authorization for using the APC Shot M59 in the Automatic Gun M9.

a. Ballistic coefficient. The firing table was computed with a ballistic coefficient of unity with respect to the modified Space and Time functions:

$$S' = 220.7\, T_8 \qquad T' = 11.25\,(I_8 - 1),$$

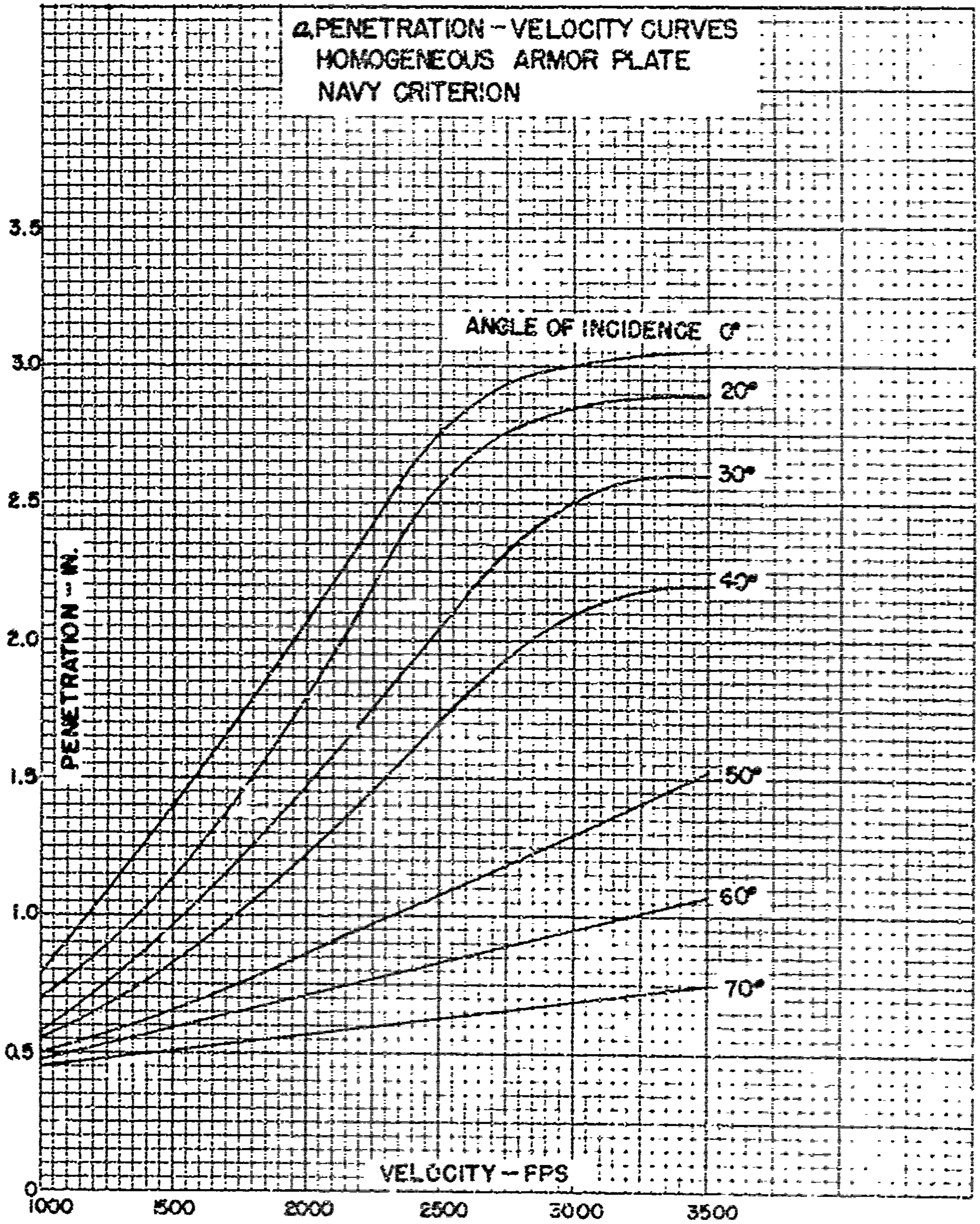
where T_8 and I_8 are the Time and Inclination functions based on G_8. This is equivalent to taking the ballistic coefficient relative to Projectile Type 8 inversely proportional to the velocity.

b. Trajectory data. The firing table gives trajectory data for firing forward from an airplane. Data for all-around fire are not required at present.

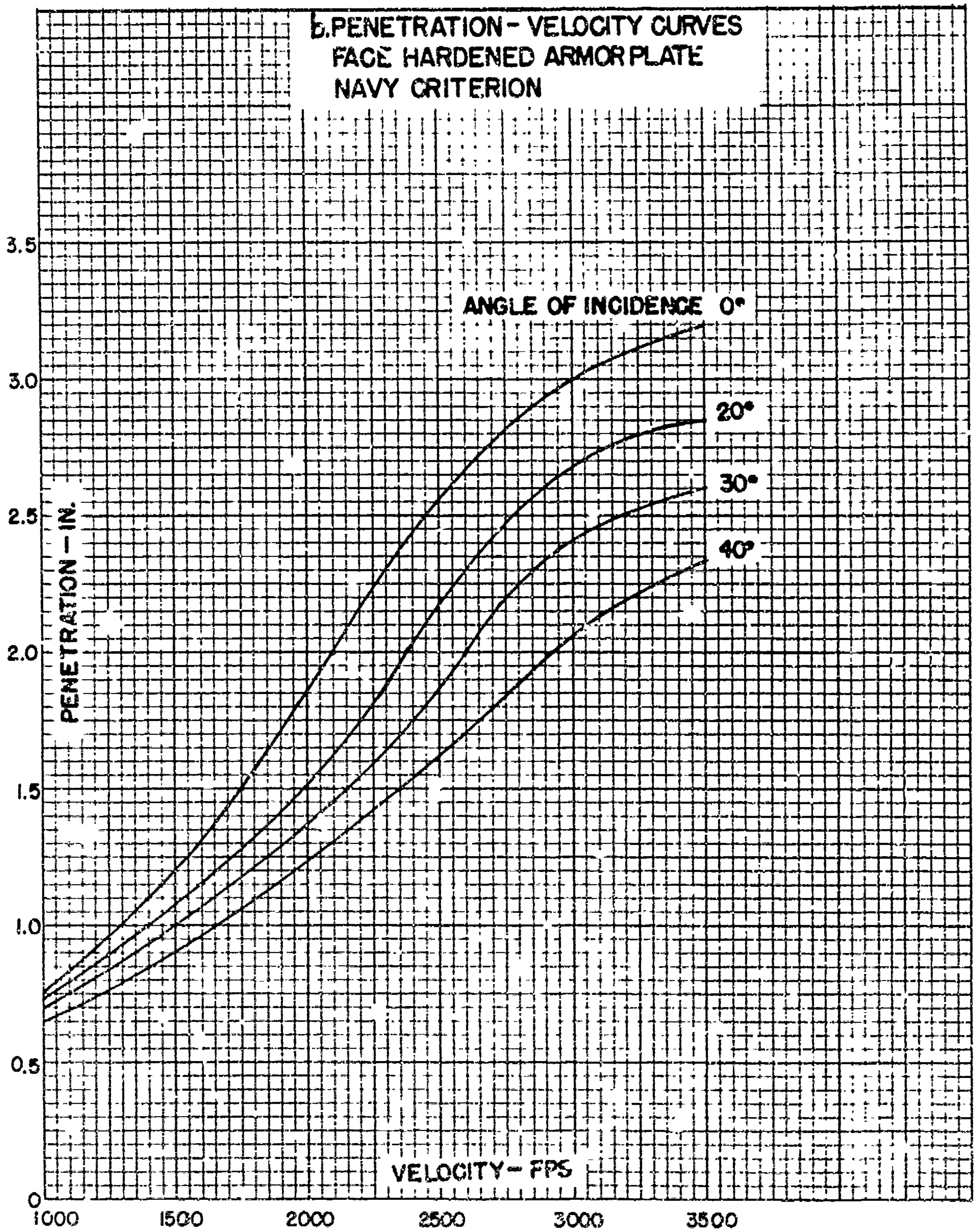
SECTION V
EFFECT DATA

Paragraph
Penetration - 9

9. Penetration. The following graphs, showing the penetration of armor plate by the 37-mm APC Shot M59, were taken from Volume III of "Terminal Ballistic Data".



a. PENETRATION – VELOCITY CURVES
HOMOGENEOUS ARMOR PLATE
NAVY CRITERION



b. PENETRATION - VELOCITY CURVES
FACE HARDENED ARMOR PLATE
NAVY CRITERION

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 37-1-80

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
23 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shot, AP, 37-mm, M80
with
Self-destroying Tracer

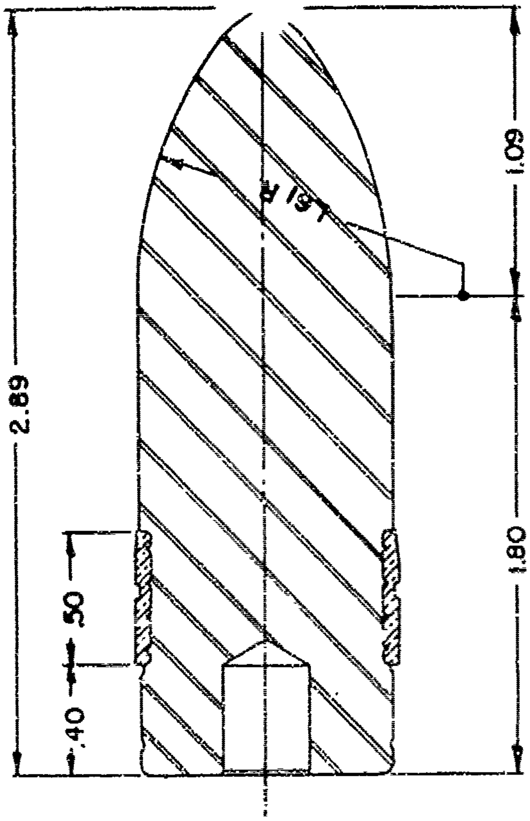
Section		Paragraphs
I	General ----------------------	1
II	Description --------------------	2 - 4
III	Interior ballistic data ---------	5
IV	Exterior ballistic data --------	6 - 8
V	Effect data -------------------	9

SECTION I
GENERAL

	Paragraph
Purpose -	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 37-mm Armor-piercing Shot M80, which contains a self-destroying tracer composition. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 1.457"



SHOT, AP, 37-MM, M80

SECTION II

DESCRIPTION

Paragraph
Drawing - 2
Dimensions - 3
Physical characteristics- 4

2. Drawing.

Shot: Metal parts assembly and details	75-2-310

3. Dimensions.

Band: Distance from base	0.40 cal
Width	0.50 cal
Cylindrical part of body: Length	1.80 cal
Ogive: Length	1.09 cal
Radius of arc	1.61 cal
Shot: Length	2.89 cal

4. Physical characteristics.

Weight (standard)	1.66 lb
Base to center of gravity	1.268 cal
Axial moment of inertia	0.4150 lb.in^2
Transverse moment of inertia	1.963 lb.in^2

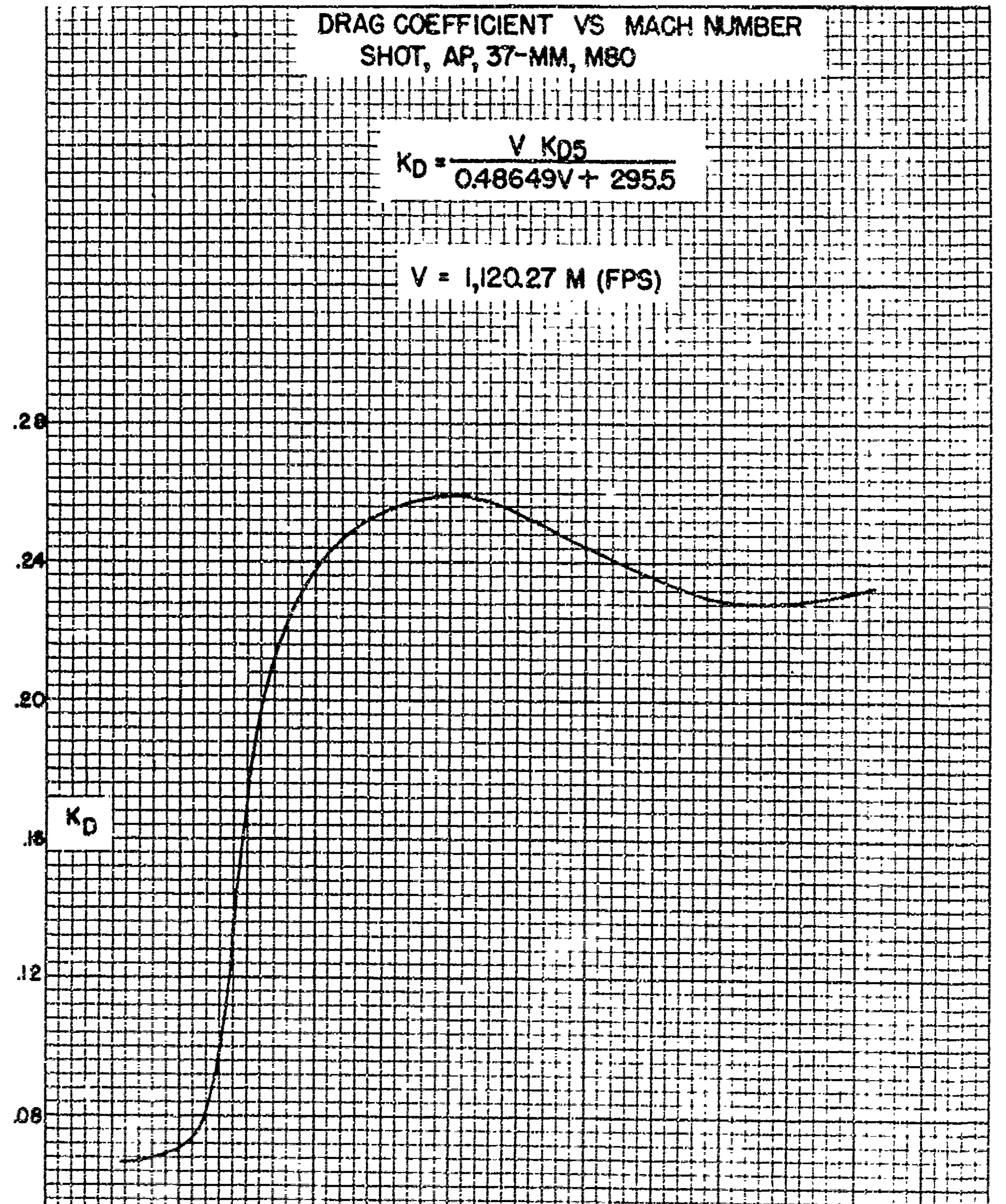
SECTION III

INTERIOR BALLISTIC DATA

Paragraph
Theoretical yaw in bore - 5

5. Theoretical yaw in bore.

Minimum	13 min
Maximum	22 min



DRAG COEFFICIENT VS MACH NUMBER
SHOT, AP, 37-MM, M80
$K_D = \frac{V\ K_{D5}}{0.48649V + 295.5}$
V = 1,120.27 M (FPS)
K_D
.28
.24
.20
.16
.12
.08
.04
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
M

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data -	6
Firing table data: Automatic Guns M4 and M10 - - - - - - - - - - - - - - - -	7
Firing table data: Automatic Gun M9 -	8

6. **Aerodynamic data** The drag coefficient plotted on page 4 was determined from resistance firings of the AP Shot M80 with Tracer at Mach numbers from 1.1 to 2.5. The other data listed below were taken from Ballistic Research Laboratory Report No. 438, "Yaw and Drift of 37-mm Armor-piercing Shots".

Velocity (fps)	u	1650	3050
Drag coefficient	K_D	0.259	0.228
Cross Wind Force coefficient	K_L		0.188
Normal Force coefficient	K_N		0.416
Base to Center of Pressure	h (cal)		2.46
Overturning Moment coefficient	K_M	0.513	0.497
Ratio of coefficients	K_L/K_M		0.378
Drift function	$Q = K_L/K_M u^2$		4.07×10^{-8}
Yawing Moment coefficient	K_H		2.53
Magnus Moment coefficient	K_J		-0.26
Twist of Rifling	$1/n$	1/25	1/30
Stability factor	s	9.5	6.785

7. **Firing table data: Automatic Guns M4 and M10 (Aircraft).**

FT 37AC-AT-1. Twist of rifling: 1/25. Muzzle velocity: 1775 fps. The M10 Gun is a modification of the M4 Gun, with a disintegrating belt feed. OCM items 17489 and 17582 recommended and approved standardization of the AP Shot M80 in the Automatic Gun M4 with a muzzle velocity of 1650 fps. OCM items 20398 and 21039 recommended and approved increasing the standard muzzle velocity from 1650 to 1855 fps.

a. Form factor. The form factor of the AP Shot M80 relative to its own drag function is $i = 1.00$. The drag coefficient curve is shown on page 4.

b. Ballistic coefficient.	$C = 0.782$
c. Stability factor (normal).	$s_s = 6.785$
d. Damping coefficients.	$c' = 0.001{,}577{,}4\ \text{ft}^{-1}$ $c'' = 0.000{,}087{,}0\ \text{ft}^{-1}$
e. Windage jump coefficient.	b = 20,200 mil. fps
f. Yaw-drag coefficient.	$K_{D\delta} = 16.4\ \text{rad}^{-2}$

g. Trajectory data. The firing table gives time of flight and vertical and lateral deflections with the arguments true air speed, zenith angle (800 to 2400 mils), azimuth (5600, 6000, 0, 400 and 800 mils), and future range for horizontal flight in air of standard surface density.

8. Firing table data: Automatic Gun M9 (Aircraft).

FT 37AC-AW-1, FT 37AC-BD-1, and FT 37AC-BE-1. Twist of rifling: 1/30. Muzzle velocity: 2950 fps. OCM items 20955 and 21241 recommended and approved authorization for using the AP Shot M80 in the Automatic Gun M9 with a standard muzzle velocity of 3050 fps.

a. Form factor. The form factor of the AP Shot M80 relative to its own drag function is $i = 1.00$. The drag coefficient curve is shown on page 4.

b. Ballistic coefficient.	$C = 0.782$
c. Stability factor (normal)	$s_s = 6.785$
d. Damping coefficients.	$c' = 0.001{,}577{,}4\ \text{ft}^{-1}$ $c'' = 0.000{,}075{,}9\ \text{ft}^{-1}$
e. Windage jump coefficient.	b = 28,000 mil. fps
f. Yaw-drag coefficient.	$K_{D\delta} = 16.4\ \text{rad}^{-2}$

g. Trajectory data.

(1) FT 37AC-AW-1 gives time of flight, elevation, and lateral deflection with the arguments air density ratio, true air speed, and future range for horizontal flight, zero azimuth, and impact on the horizontal plane thru the line of flight.

(2) FT 37AC-BD-1 gives time of flight and vertical and lateral deflections with the arguments true air speed, zenith angle (800 to 2400 mils), azimuth (5600, 6000, 0, 400 and 800 mils), and future range for horizontal flight in air of standard surface density.

(3) FT 37AC-BE-1 gives time of flight and vertical deflection with the arguments true air speed, dive angle (0, 200 and 400 mils), and present range for firing forward from an airplane in air of standard surface density.

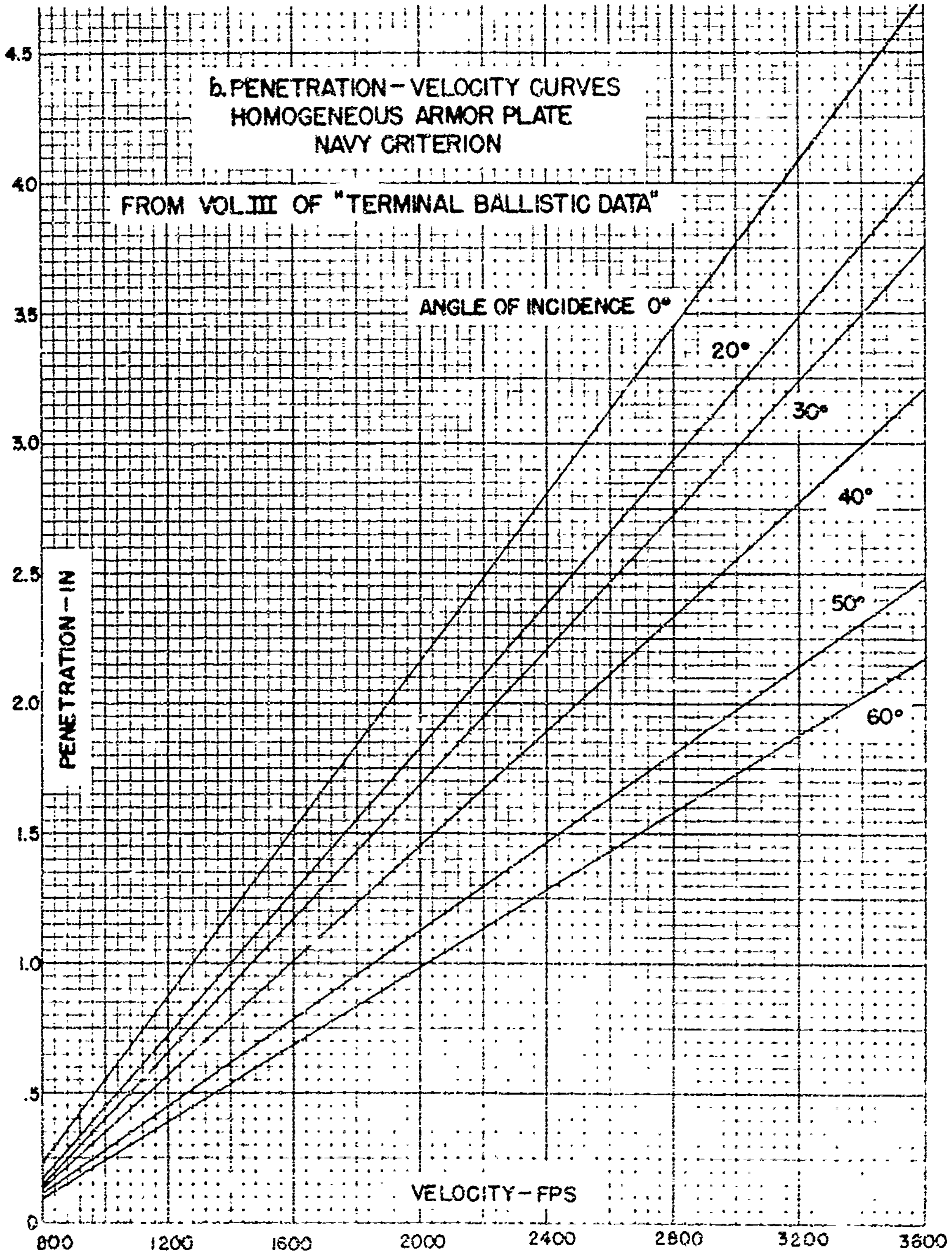
SECTION V
EFFECT DATA

Paragraph
Penetration - 9

9. Penetration.

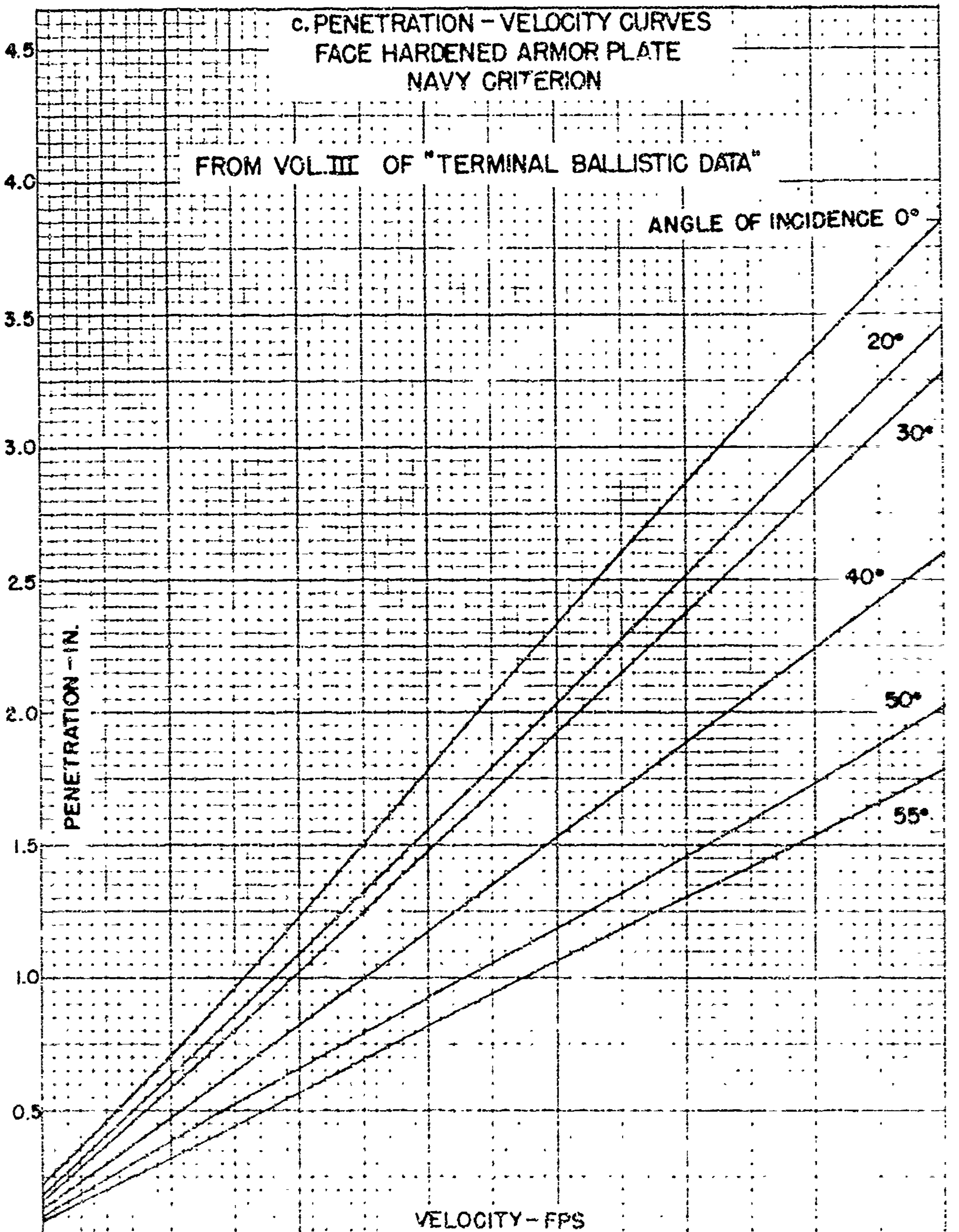
a. Ballistic limits.

Homogeneous Plate			Ballistic Limit		Number in Average
Thickness inches	Brinnell number	Obliquity deg	Type	fps	
0.75	317	0	Navy	1159	4
0.75	356	0	Navy	1093	3
1.00	327	0	Navy	1288	6
1.00	369	0	Navy	1251	1
1.00	401	0	Navy	1203	1



b. PENETRATION – VELOCITY CURVES
HOMOGENEOUS ARMOR PLATE
NAVY CRITERION

FROM VOL. III OF "TERMINAL BALLISTIC DATA"


c. PENETRATION – VELOCITY CURVES
FACE HARDENED ARMOR PLATE
NAVY CRITERION
FROM VOL. III OF "TERMINAL BALLISTIC DATA"
ANGLE OF INCIDENCE 0°
20°
30°
40°
50°
55°
PENETRATION – IN.
VELOCITY – FPS
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
800
1200
1600
2000
2400
2800
3200
3600

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 40-1-2

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
1 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 40-mm, Mark 2
with
Tracer, SD, Mark 11, Mark 11 Mod 2, M3 or M3A1
and
Fuze, PD, Mark 27 or M71

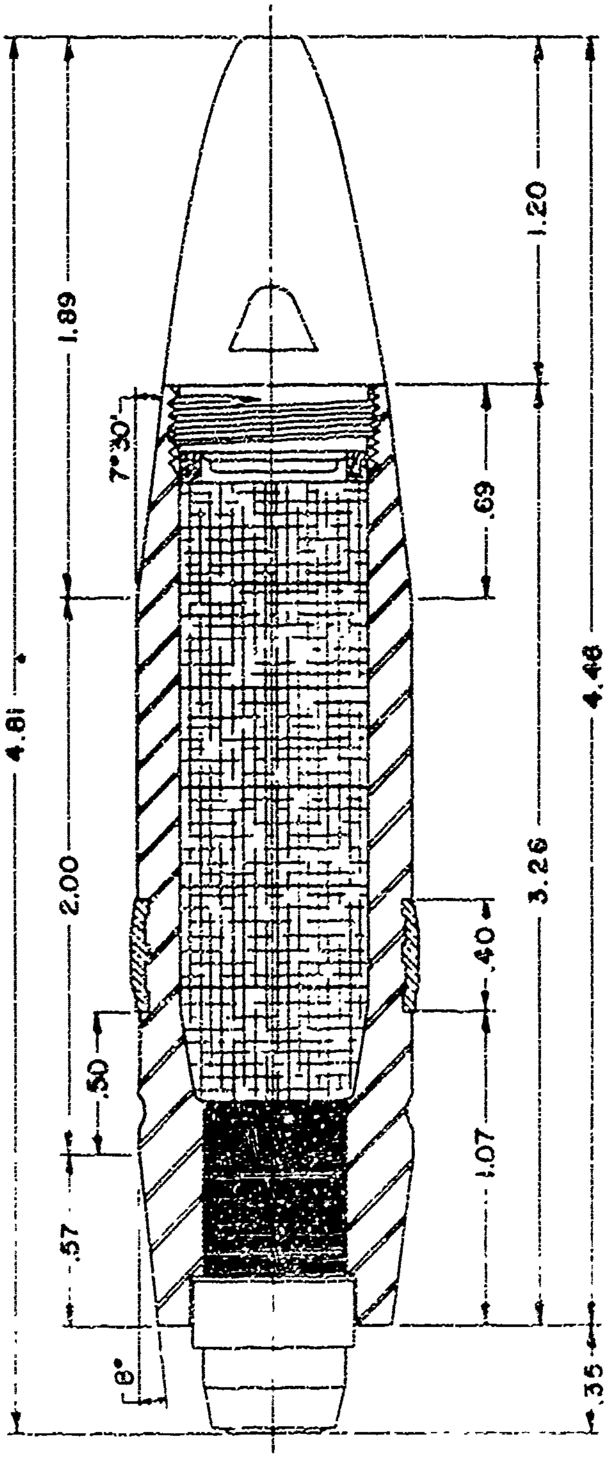
Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 8
V	Effect data	9

SECTION I
GENERAL

	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics and ballistics of the 40-mm High Explosive Shell Mark 2 with Shell - destroying Tracer Mark 11, Mark 11 Modification 2, M3 or M3A1 and Point Detonating Fuze Mark 27 or M71. This information is collected from the drawings, reports and firing tables pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 2.244"



SHELL, HE, 40-MM, MARK 2
TRACER, SD, MARK 11
FUZE, PD, MARK 27

SECTION II

DESCRIPTION

Paragraph
Drawings - 2
Dimensions - 3
Physical characteristics - 4

2. Drawings.

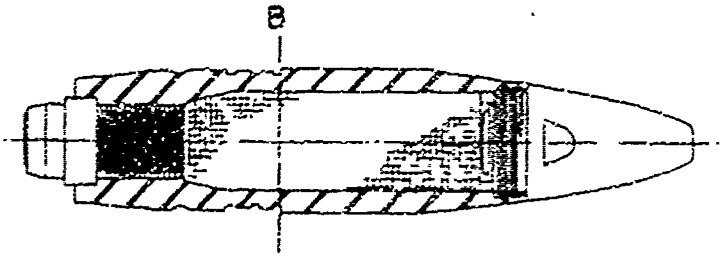
Shell: Metal parts assembly and details	75-2-298
Tracer, SD, Mark 11 (Navy BuOrd)	394,440
Tracer, SD, Mark 11 Mod 2 (Navy BuOrd)	423,429
Tracer, SD, M3 or M3A1	75-17-7
Fuze, Detonating, Mark 27: General arrangement and details (Navy BuOrd)	300,423
Fuze, PD, M71: Assembly	73-2-201
Cartridge, HE-T (SD, Mk 11), Mark 2: Assembly and marking diagram	75-1-168

3. Dimensions.

Boattail:	Angle	8°00'
	Length	0.57 cal
Band:	Distance from boattail	0.50 cal
	Distance from base	1.07 cal
	Width	0.40 cal
Cylindrical body:	Length	2.00 cal
Head:	Angle	7°30'
	Length	0.69 cal
Tracer:	Outside length	0.35 cal
Fuze:	Outside length	1.20 cal
Length:	Shell	3.26 cal
	Shell and fuze	4.46 cal
	Shell, tracer and fuze	4.81 cal
	Head and fuze	1.89 cal

4. Physical characteristics. Standard weight: 1.985 lb. The following data pertain to inert-loaded shell with wooden tracer plug and Dummy Fuze T34.

Weight	1.8285 lb
Base to center of gravity	1.566 cal
Axial moment of inertia	0.6298 lb. in^2
Transverse moment of inertia	4.955 lb. in^2



SECTION
B

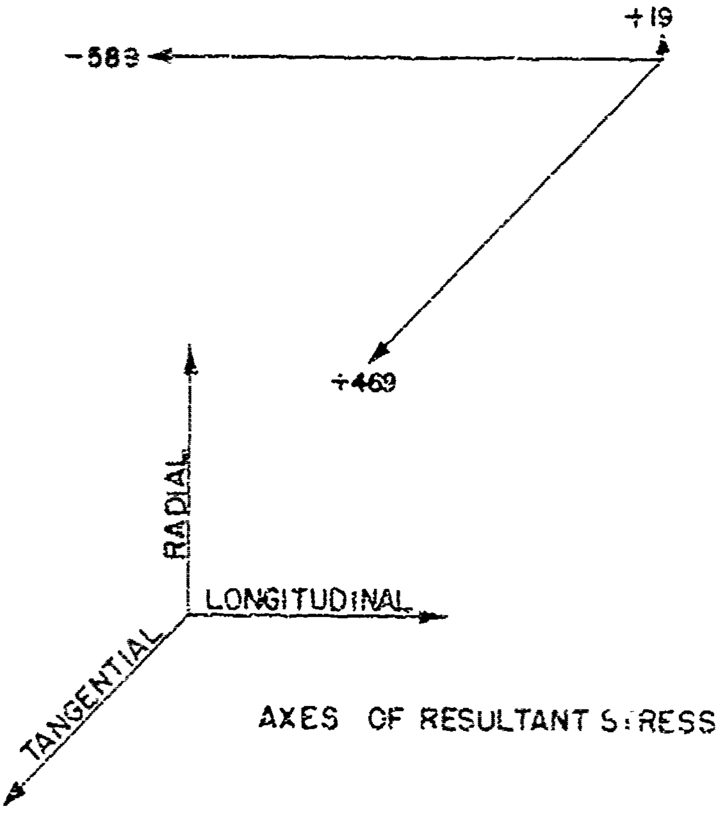


DIAGRAM OF RESULTANT STRESSES

SECTION III

INTERIOR BALLISTIC DATA

Paragraph
Stresses - 5
Theoretical yaw in bore - 6

5. **Stresses.** The following table and the graphical representation on page 4 show the longitudinal, radial and tangential stress at the front end of the band seat.

Gun, Automatic, 40-mm	M1 and M2	
Travel to maximum pressure	8.8	in.
Twist of rifling at max P	1/42.4	
Cross-sectional area of bore	2.0323	sq in.
Rated maximum pressure	40,000	psi
Total weight of projectile	1.985	lb
Muzzle velocity	2,870	fps
Density of filler (TNT)	0.057	lb per cu in.
Resultant stress:		
Longitudinal	58,900	psi (compression)
Radial	1,900	psi (tension)
Tangential	46,900	psi (tension)

6. **Theoretical yaw in bore.**

Minimum	20 min
Maximum	26 min

SECTION IV

EXTERIOR BALLISTIC DATA

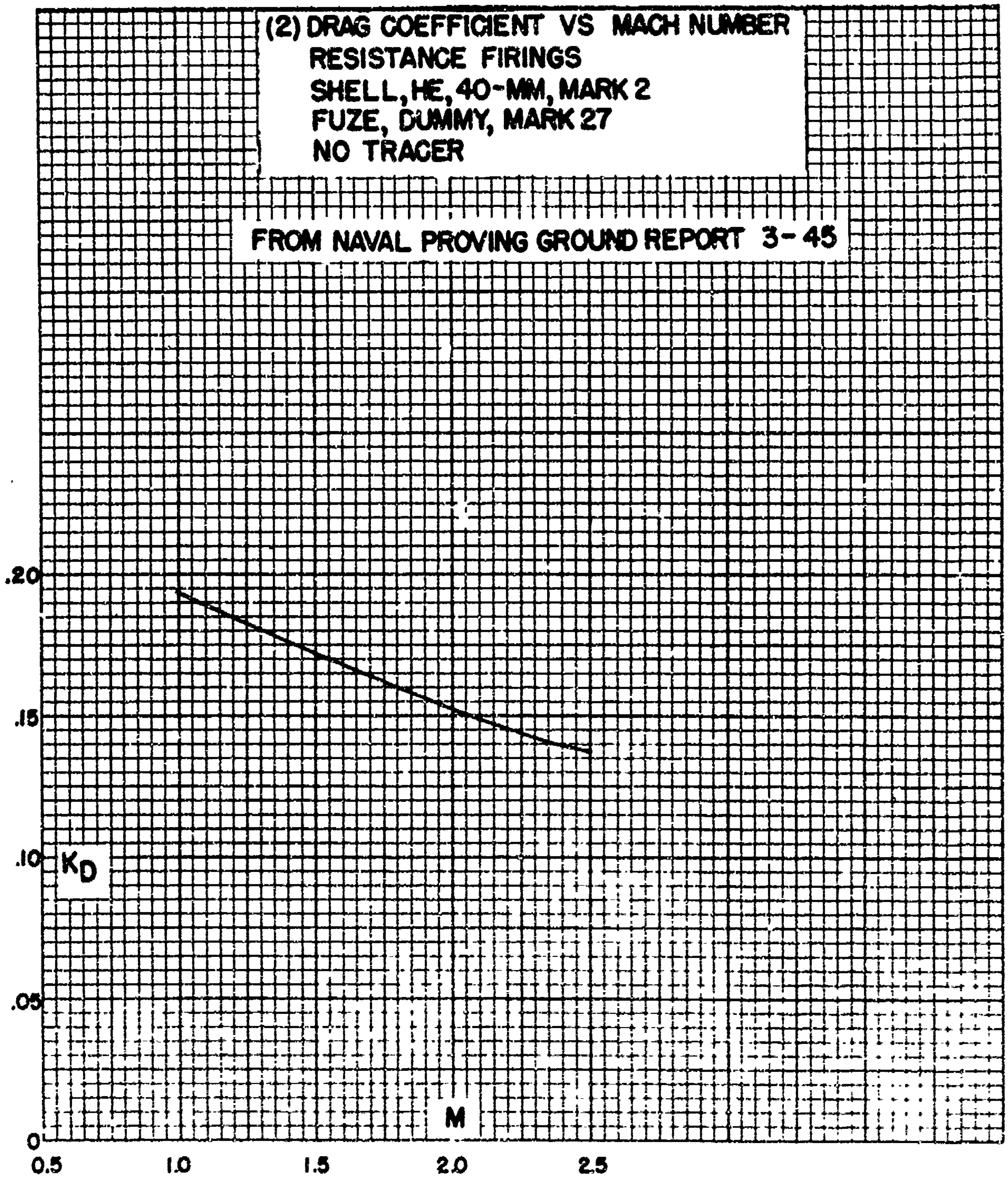
Paragraph
Aerodynamic data - 7
Firing table data - 8

7. **Aerodynamic data.**

a. Drag.

(1) Time-of-flight firings. 40-mm HE Shell Mark 2.

Fuze	Tracer	Velocity fps	Drag Function	Form Factor	Drag Coef.
M64A1	M3	2867	G_5	.952	.128
Mk 27	Mk 11	2396	G_5	.927	.124



(2) DRAG COEFFICIENT VS MACH NUMBER
RESISTANCE FIRINGS
SHELL, HE, 40-MM, MARK 2
FUZE, DUMMY, MARK 27
NO TRACER

FROM NAVAL PROVING GROUND REPORT 3-45

b. **Stability.** Ballistic Research Laboratory Report No. 252, "Stability of 40-mm Shell Mark II T/L/", gives aerodynamic data for inert-loaded shell with Dummy Fuze T34. A wooden plug was inserted in the tracer cavity, but it came out when the shell was fired. The stability firings were done with a Bofors Gun containing a tube that was rifled with a final twist of 1/30.

Velocity fps	Mach No.	Stability Factor	Moment Coefficient
1200	1.042	1.23	1.85
2890	2.514	1.48	1.54

8. **Firing table data.** FT 40AA-A-3.

Guns, Automatic, 40-mm, M1 and Dual, Automatic, 40-mm, M2. Twist of rifling: Increasing, 1/45 to 1/30. MV: 2800 fps (the MV for a new gun is 2870 fps). Weight of Shell with Tracer and Fuze: 1.985 lb. OCM items 17175 and 17250 recommended and approved the standardization of the Quick Firing High Explosive Shell Mark 2 with Tracer and Delay Action Percussion Fuze No. 251 Mark 1. OCM items 20391 and 20739 recommended and approved the reclassification of the Detonating Fuze Mark 27 from substitute standard to standard and the adoption of the Point Detonating Fuze M71 as alternate standard. The Shell-destroying Tracers Mark 27 and Mark 27 Mod 2 are standard; the Shell-destroying Tracers M3 and M3A1 are alternate standard.

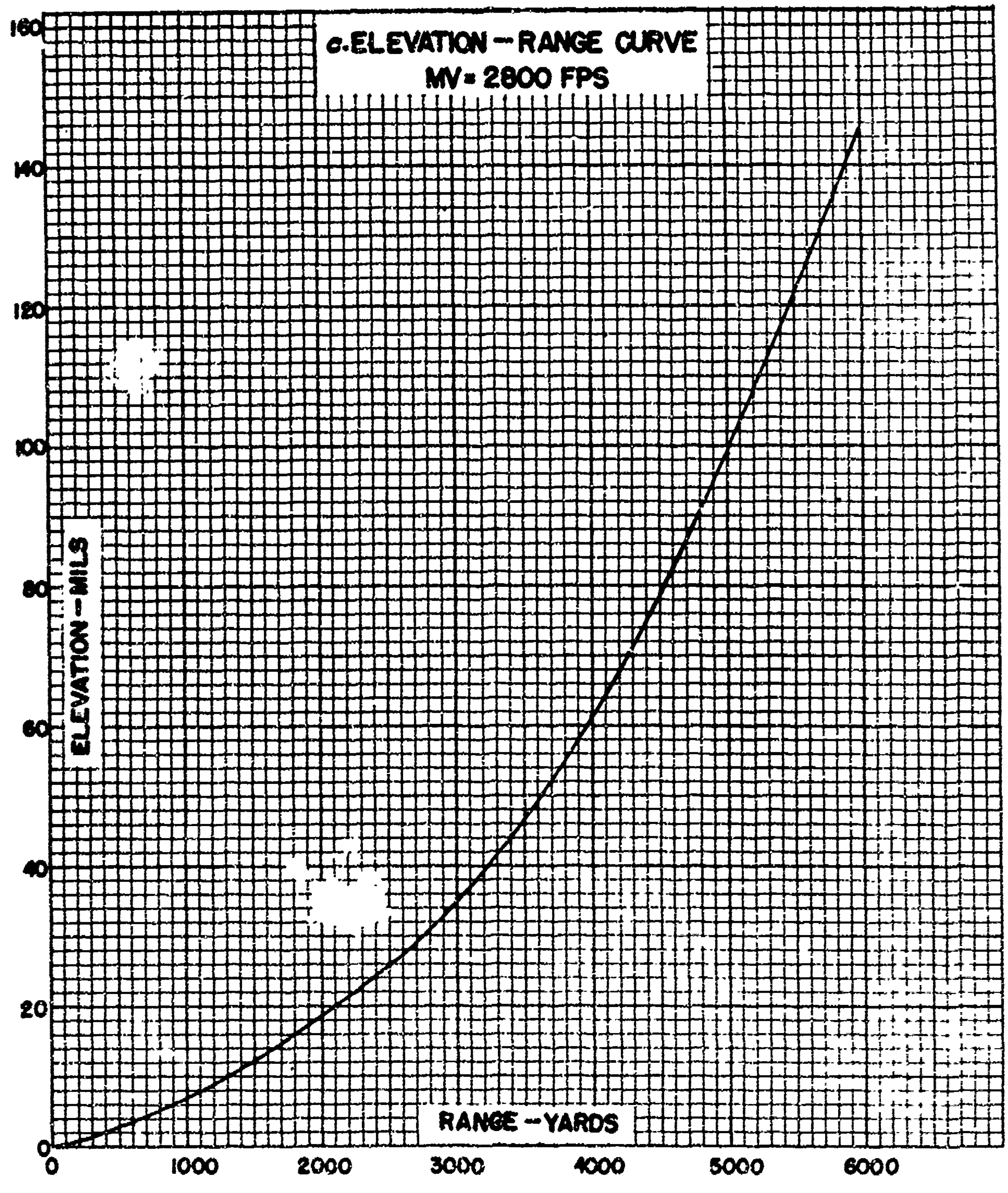
a. **Form factor and ballistic coefficient** (Projectile Type 5). At all elevations:

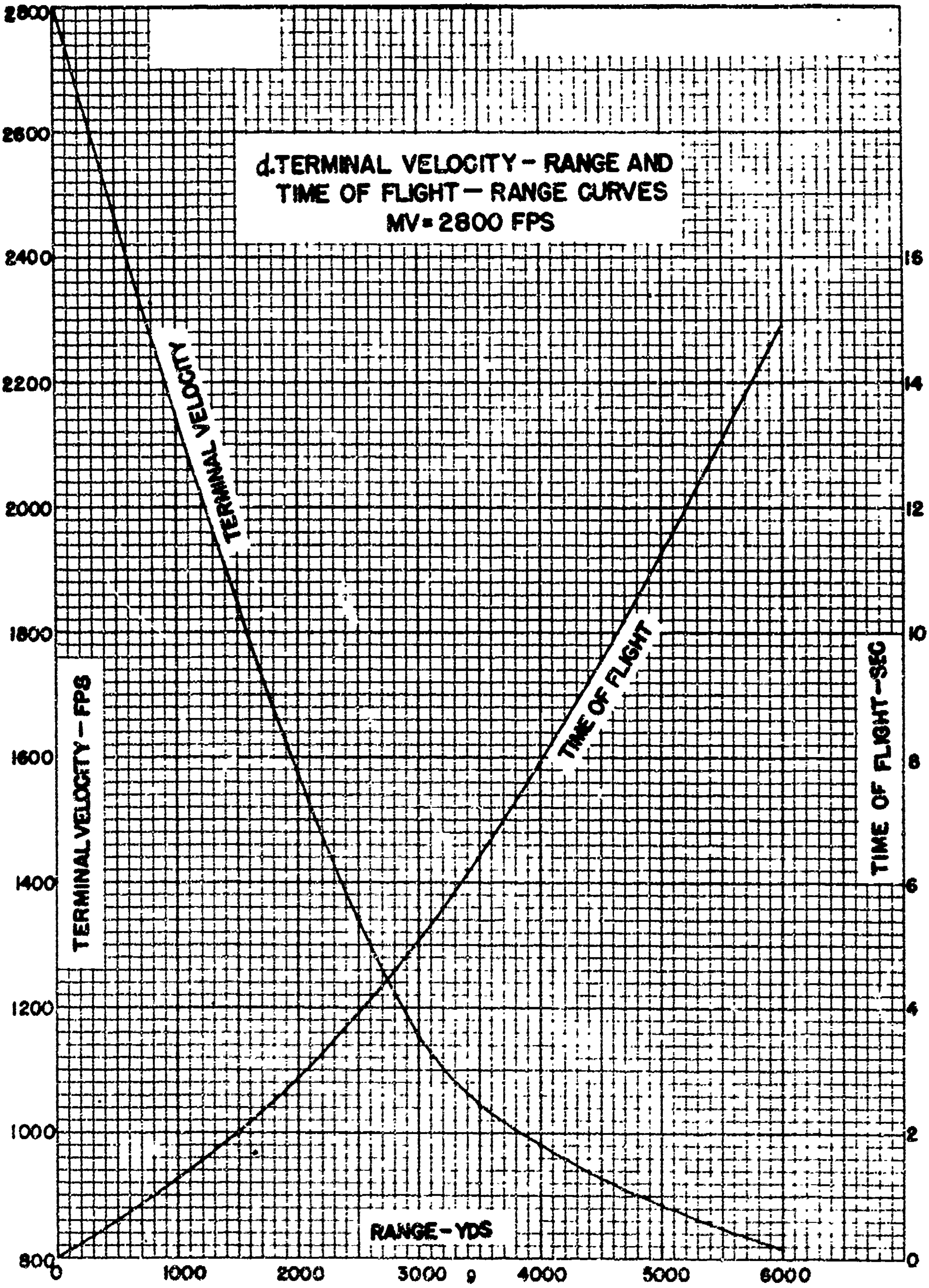
$i_5 = 0.947$

$C_5 = 0.845$

b. **Trajectory data.** Part I of the firing tables contains trajectory data for antiaircraft fire; Part II, differential effects; and the Appendix, trajectory and time curves.

Maximum horizontal range	10,850 yd
Maximum ordinate	7,625 yd


a. ELEVATION — RANGE CURVE
MV = 2800 FPS
ELEVATION — MILS
RANGE — YARDS
0
20
40
60
80
100
120
140
160
0
1000
2000
3000
4000
5000
6000



d. TERMINAL VELOCITY – RANGE AND
TIME OF FLIGHT – RANGE CURVES
MV = 2800 FPS
TERMINAL VELOCITY
TIME OF FLIGHT
TERMINAL VELOCITY – FPS
TIME OF FLIGHT – SEC
RANGE – YDS
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
0
1000
2000
3000
4000
5000
6000
16
14
12
10
8
6
4
2
0

SECTION V

EFFECT DATA

Paragraph
Fragmentation - 9

9. **Fragmentation.** No fragmentation tests of the 40-mm Shell Mark 2 with its standard loading of TNT have been conducted here, but Picatinny Arsenal has detonated five Shell Mark 2 loaded with Ednatol (50 to 60% ethylenedinitramine and 50 to 40% trinitrotoluene) in a sand pit, and recovered the fragments (Test Record No. 134-6). The average weight of the loaded shell was 1.795 lb; of the empty shell, 1.615 lb. The following table shows the average number and weight of the fragments in each of four groups.

Weight Zone grains	Number of Fragments	Weight of Fragments lb	Percent of Empty Shell Recovered
0 - 75	197	0.60	
75 - 150	14	0.23	
150 - 750	13	0.45	
750 - 2500	1	0.24	
Total	226	1.53	94.7

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 40-1-81

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
2 March 1949

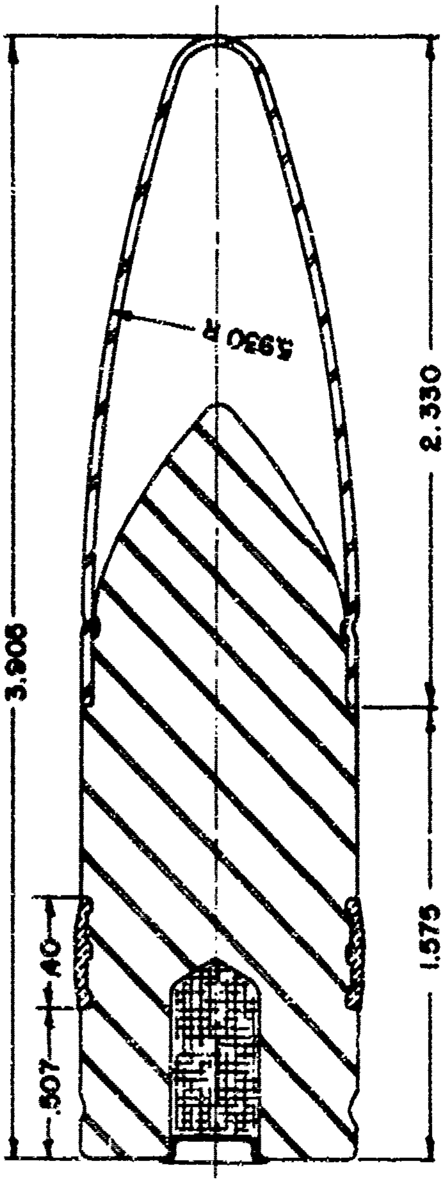
BALLISTIC AND ENGINEERING DATA
for
Shot, AP, 40-mm, M81 or M81A1
with Tracer

Section		Paragraph
I	General - - - - - - - - - - - -	1
II	Description - - - - - - - - - -	2 - 4
III	Interior ballistic data - - - -	5
IV	Exterior ballistic data - - - -	3 - 7
V	Effect data - - - - - - - - - -	8

SECTION I
GENERAL

	Paragraph
Purpose -	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 40-mm Armor-piercing Shot M81 or M81A1 with Tracer. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.



ALL DIMENSIONS IN CALIBERS
1 CAL. = 1.575"

SHOT, AP, 40-MM, M81A1

SECTION II

DESCRIPTION

	Paragraph
Drawings -	2
Dimensions -	3
Physical characteristics -	4

2. Drawings.

Shot: Metal parts assembly	75-2-311
Details	75-2-312
Tracer	75-14-333

3. Dimensions.

Band: Distance from base	0.507 cal
Width	0.400 cal
Body: Cylindrical length	1.575 cal
Windshield: Length	2.330 cal
Radius of ogival arc	5.930 cal
Shot: Total length	3.905 cal

4. Physical characteristics.

Weight (standard)	1.96 lb
Base to center of gravity*	1.21 cal
Axial moment of inertia*	0.574 lb. in^2
Transverse moment of inertia*	2.64 lb. in^2

* Estimated on the basis of measurements of the 37-mm Armor-piercing Capped Shop M51.

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore -	5

5. Theoretical yaw in bore.

Minimum	25 min
Maximum	32 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data -	6
Firing table data -	7

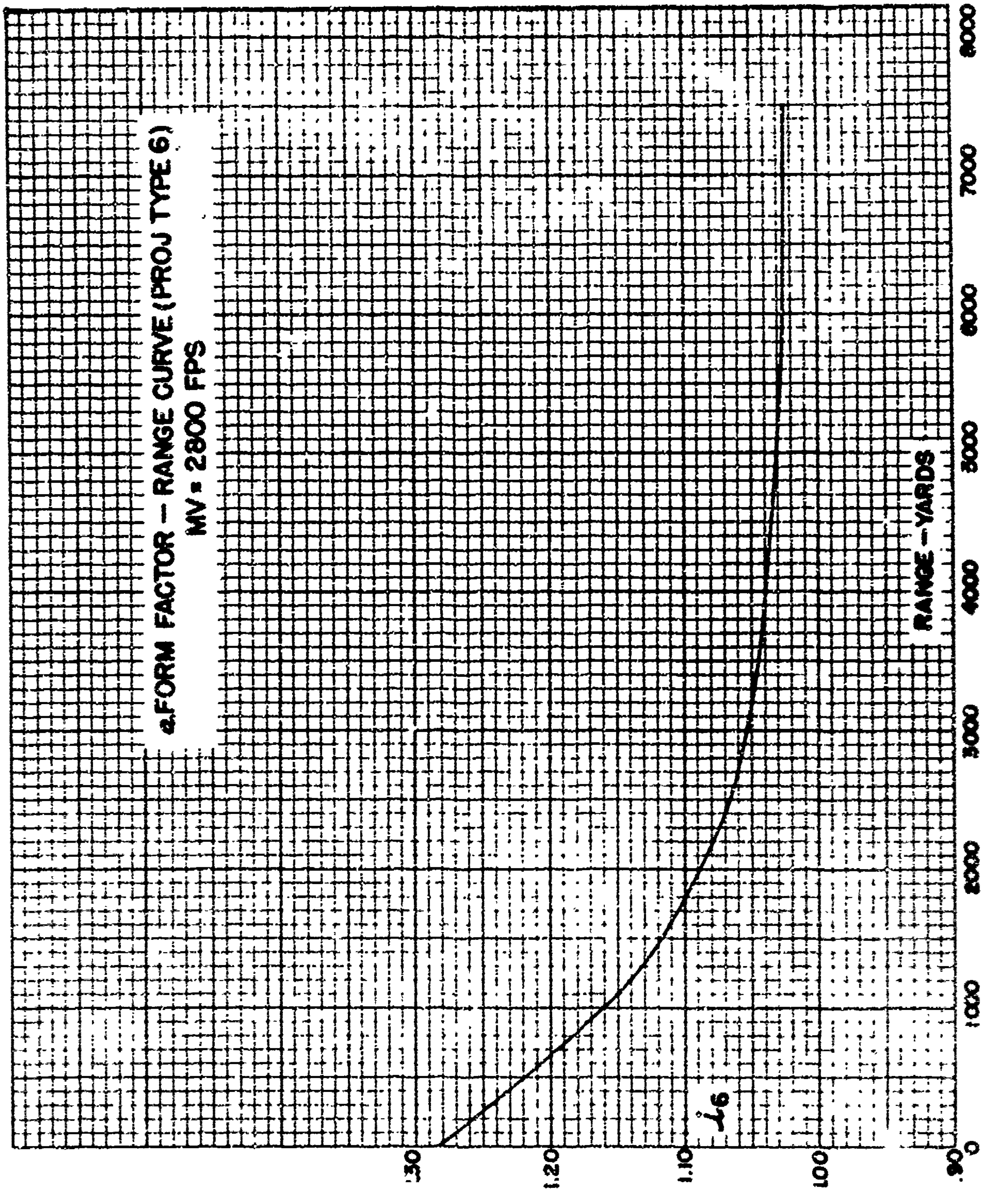
6. Aerodynamic data.

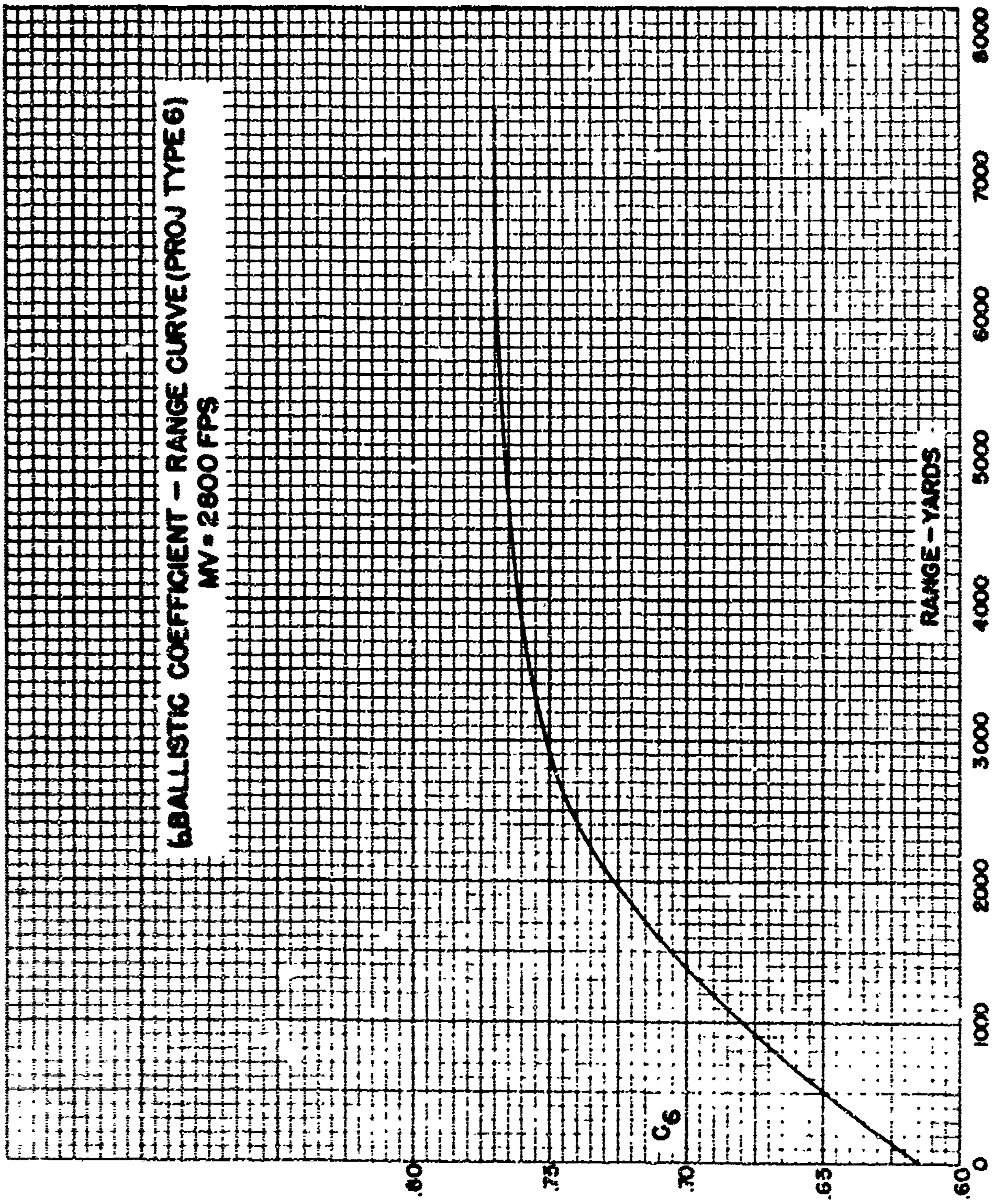
a. Drag. With the G_6 drag function, the ballistic coefficient was determined from the time of flight at 600, 1000 and 1500 yards and the elevation at 7500 yards range. The extrapolated value at zero range is 0.615 (see par. 7b). The corresponding form factor, relative to Projectile Type 6, is 1.285. Hence, the drag coefficient is 0.142 at the standard muzzle velocity of 2870 fps. These data were obtained with the AP Shot M81, but are applicable to the AP Shot M81A1, since its contour is only slightly different.

b. Stability. No stability firings have been done with the 40-mm AP Shot M81 or M81A1. The stability factor, estimated from that of the 37-mm Armor-piercing Capped Shot M51 (given in Ballistic Research Laboratory Report No. 225, "Stability of 37-mm HE Shell M63, AP Shot M51, and Proof Projectile M52") at velocities of 1350 and 2750 fps, for a twist of rifling of one turn in 30 calibers, is 2.58.

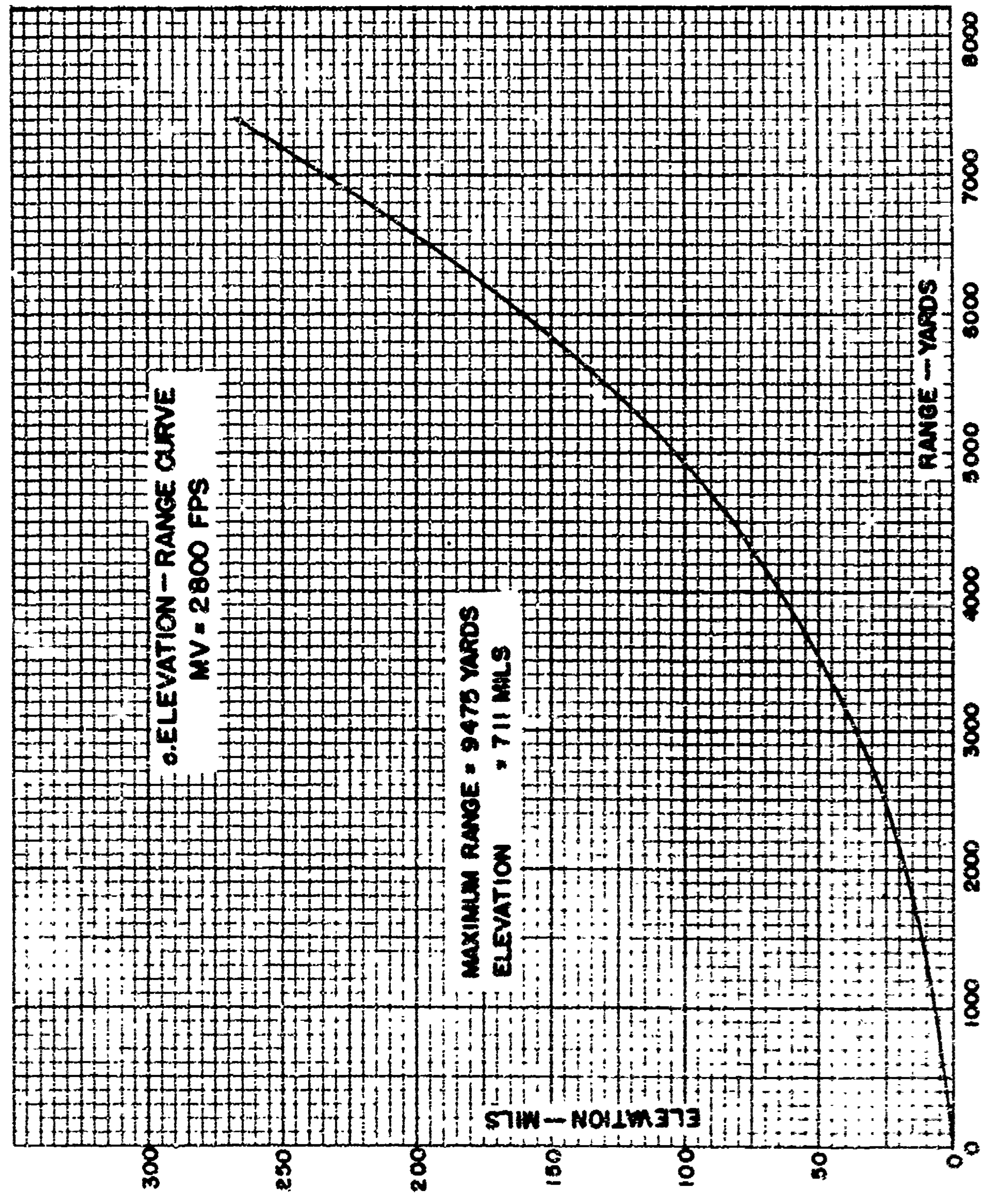
7. Firing table data. FT 40AA-A-3.

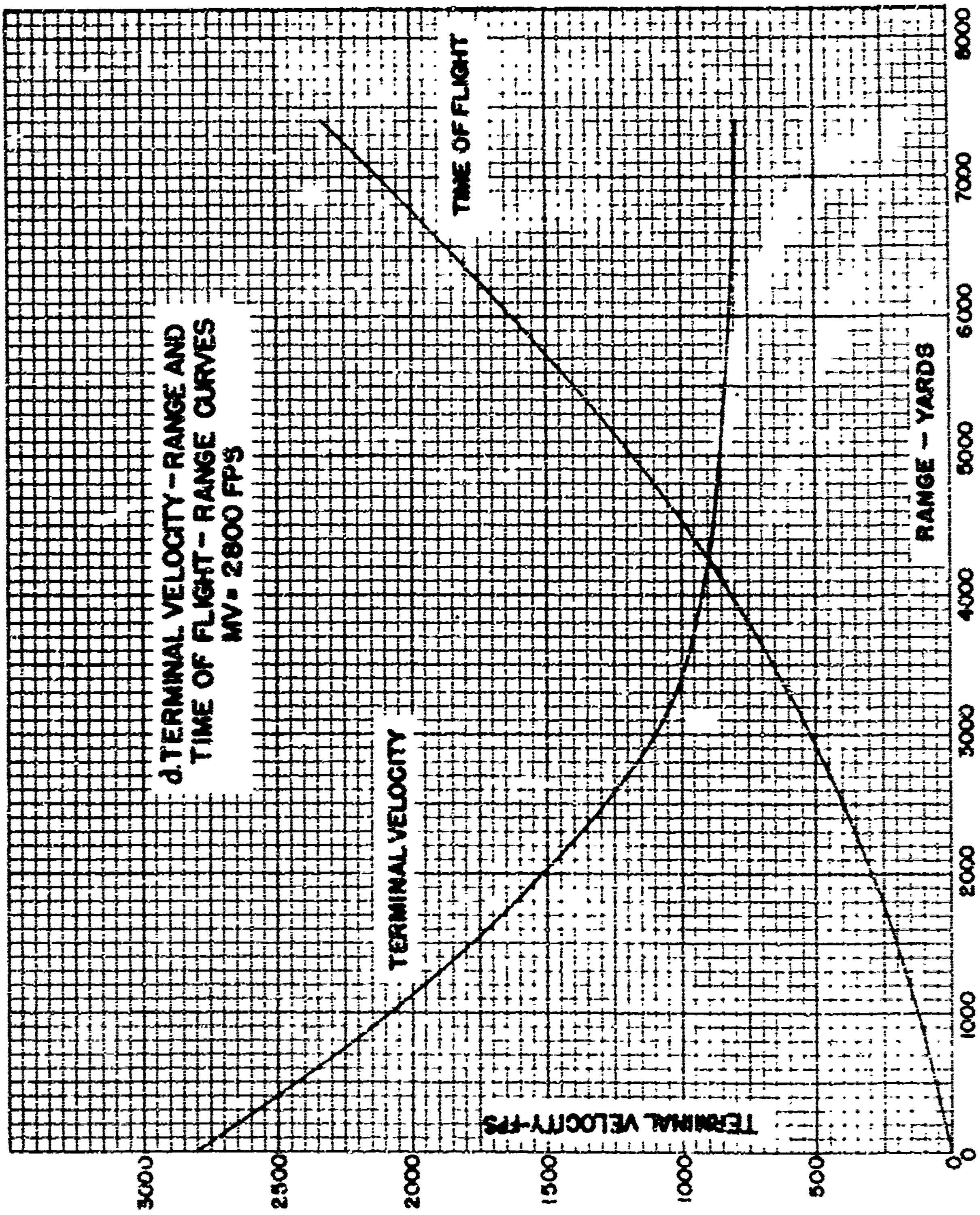
Guns, Automatic, 40-mm, M1 and Dual, Automatic, 40-mm, M2. Twist of rifling: increasing, 1/45 to 1/30. MV: 2800 fps (the MV for a new gun is 2870 fps). Weight of Shot with Tracer: 1.96 lb. OCM items 17676 and 17750 recommended and approved standardization of the Armor-piercing Shot M81. The M81 Shot is now classified as limited standard, and the M81A1 standard.


a FORM FACTOR — RANGE CURVE (PROJ TYPE 6)
MV = 2800 FPS
RANGE — YARDS
0
1000
2000
3000
4000
5000
6000
7000
8000
i_6
.90
1.00
1.10
1.20
1.30



6. BALLISTIC COEFFICIENT — RANGE CURVE (PROJ TYPE 6)
MV = 2800 FPS


c.ELEVATION – RANGE CURVE
MV = 2800 FPS
MAXIMUM RANGE = 9475 YARDS
ELEVATION = 711 MILS
RANGE — YARDS
ELEVATION — MILS
0
1000
2000
3000
4000
5000
6000
7000
8000
0
50
100
150
200
250
300



d. TERMINAL VELOCITY - RANGE AND TIME OF FLIGHT - RANGE CURVES MV = 2800 FPS

SECTION V

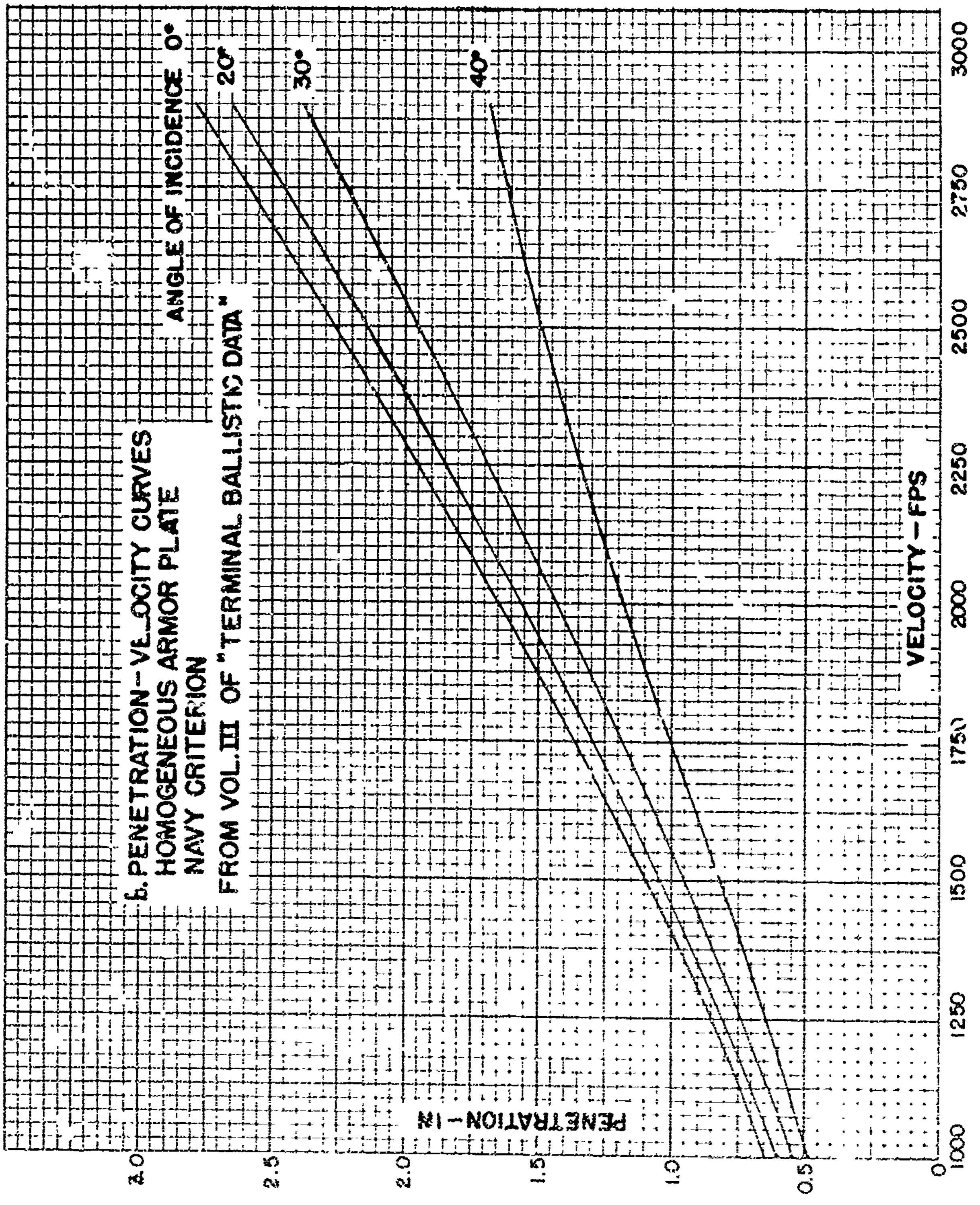
EFFECT DATA

Paragraph
Penetration - 8

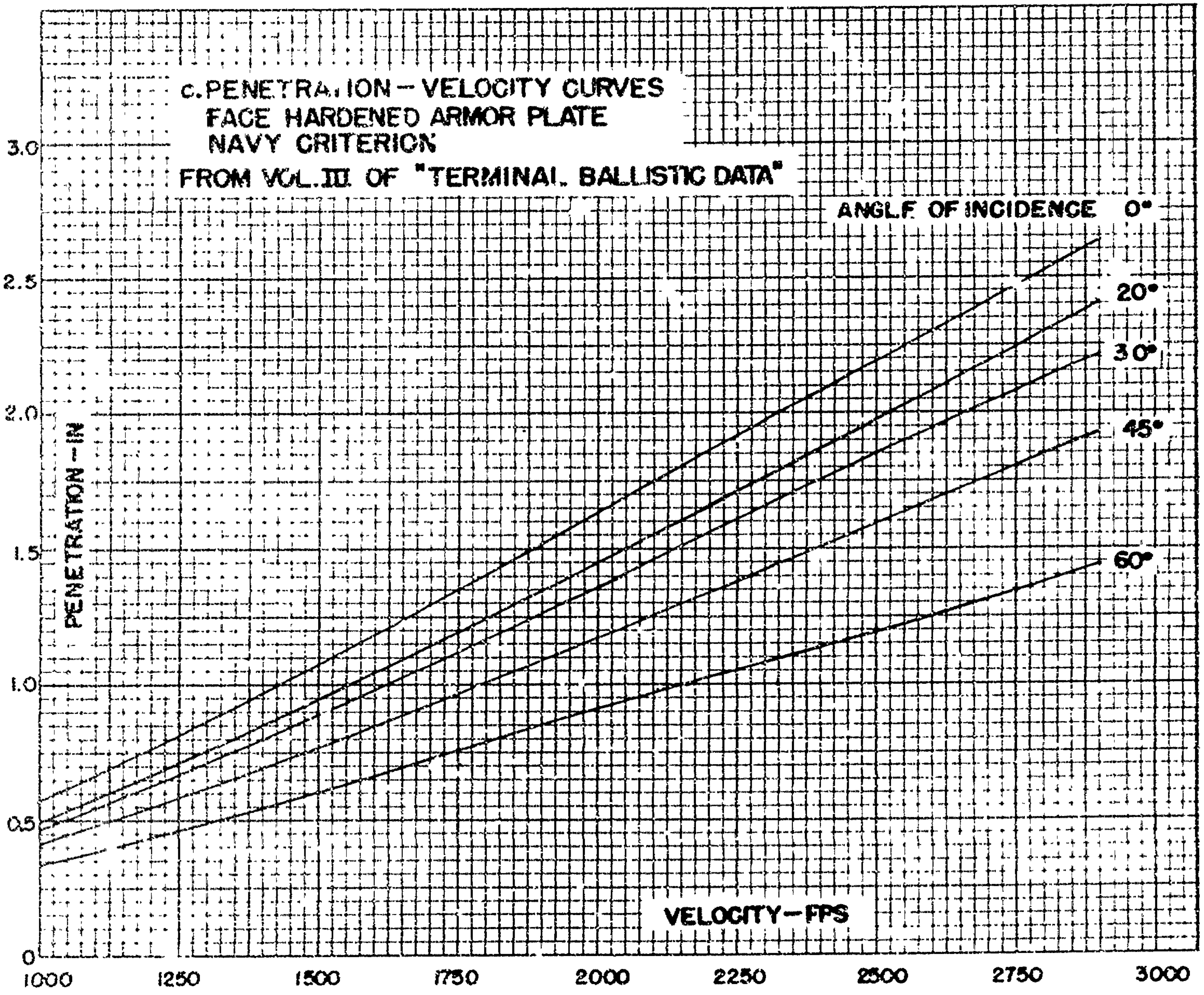
8. **Penetration.**

a. **Ballistic limits.**

Plate Thickness: 1.5 in. Obliquity: 20°	Ballistic Limit Type	 fps	Number in Average
Face-hardened	Army	2004	4
	Navy	1972	39
Homogeneous:			
Brinnel No. 269	Army	2088	12



b. PENETRATION-VELOCITY CURVES
HOMOGENEOUS ARMOR PLATE
NAVY CRITERION
FROM VOL. III OF "TERMINAL BALLISTIC DATA"



c. PENETRATION – VELOCITY CURVES
FACE HARDENED ARMOR PLATE
NAVY CRITERION
FROM VOL. III OF "TERMINAL BALLISTIC DATA"

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 57-1-306

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
2 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 57-mm, M306
with
Fuze, PD, M89

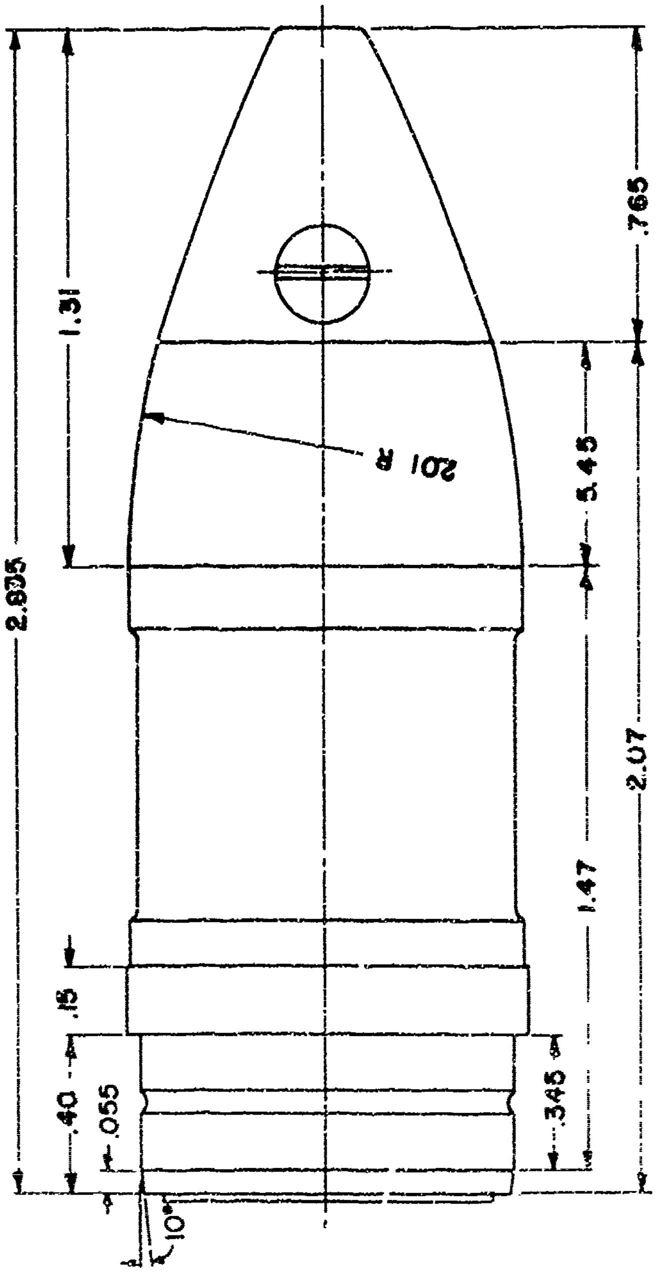
Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5
IV	Exterior ballistic data	6 - 7
V	Effect data	8 - 9

SECTION I
GENERAL

	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 57-mm High Explosive Shell M306 with the Point Detonating Fuze M89. This information is collected from the drawings, reports, firing tables, and firing records pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 2.244"



SHELL, HE, 57-MM, M306
FUZE, PD, M89

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell: Metal parts assembly and details	75-2-359
Fuze: Assembly and details	73-2-233
Details	73-2-234 and 235

3. Dimensions.

Chamfer: Angle	10°
Length	0.055 cal
Band: Distance from chamfer	0.345 cal
Distance from base	0.40 cal
Width	0.15 cal
Cylindrical body: Length	1.47 cal
Ogive: Length	0.545 cal
Radius of arc	2.01 cal
Fuze: Length (outside)	0.765 cal
Length: Shell	2.07 cal
Shell and fuze	2.835 cal
Ogive and fuze	1.31 cal

4. Physical characteristics.

Weight (standard)	2.75 lb
Weight (as tested) *	2.86 lb
Base to center of gravity	1.237 cal
Axial moment of inertia	2.18 lb. in^2
Traverse moment of inertia	9.89 lb. in^2

* See BRL Memo Reports 300 and 348D.

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore -	5

5. Theoretical yaw in bore.

Minimum	11 min
Maximum	18 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data -	6
Firing table data -	7

6. Aerodynamic data.

a. Drag.

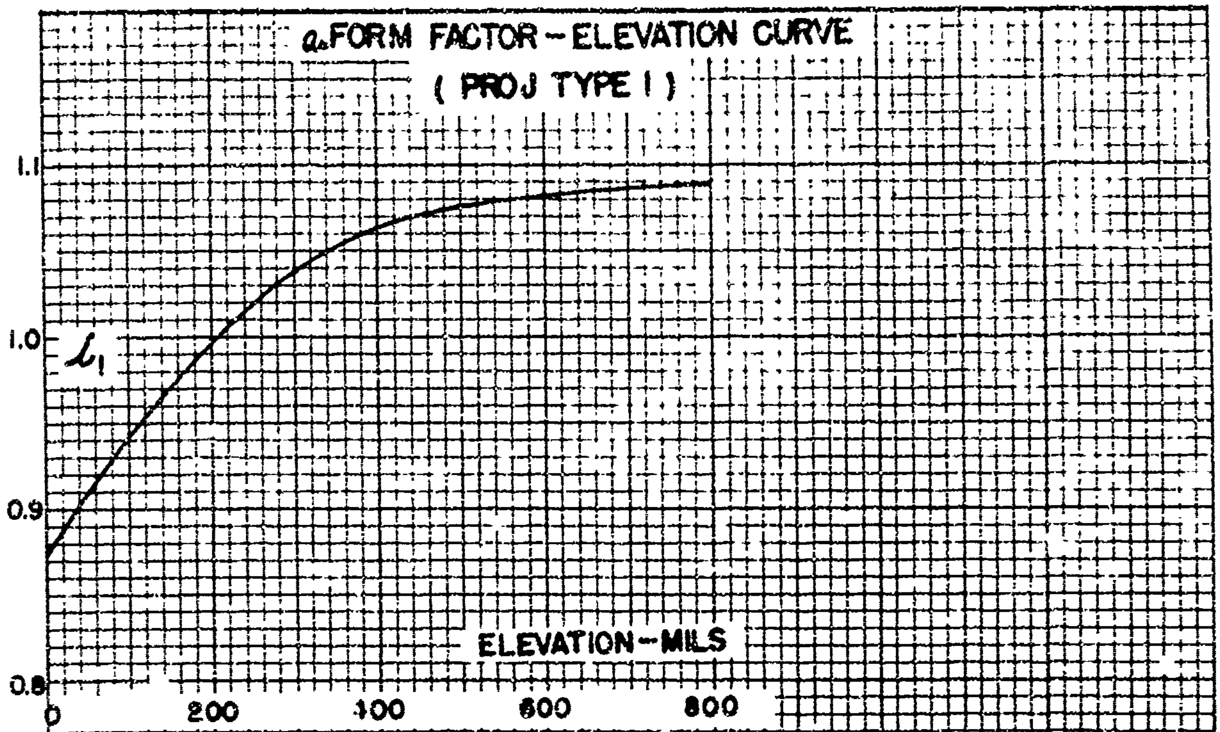
Drag function				G_1
Form factor (from time of flight)				0.86
Velocity (fps):	Muzzle	1200	Mean	978
Drag coefficient, K_D		0.191		0.105

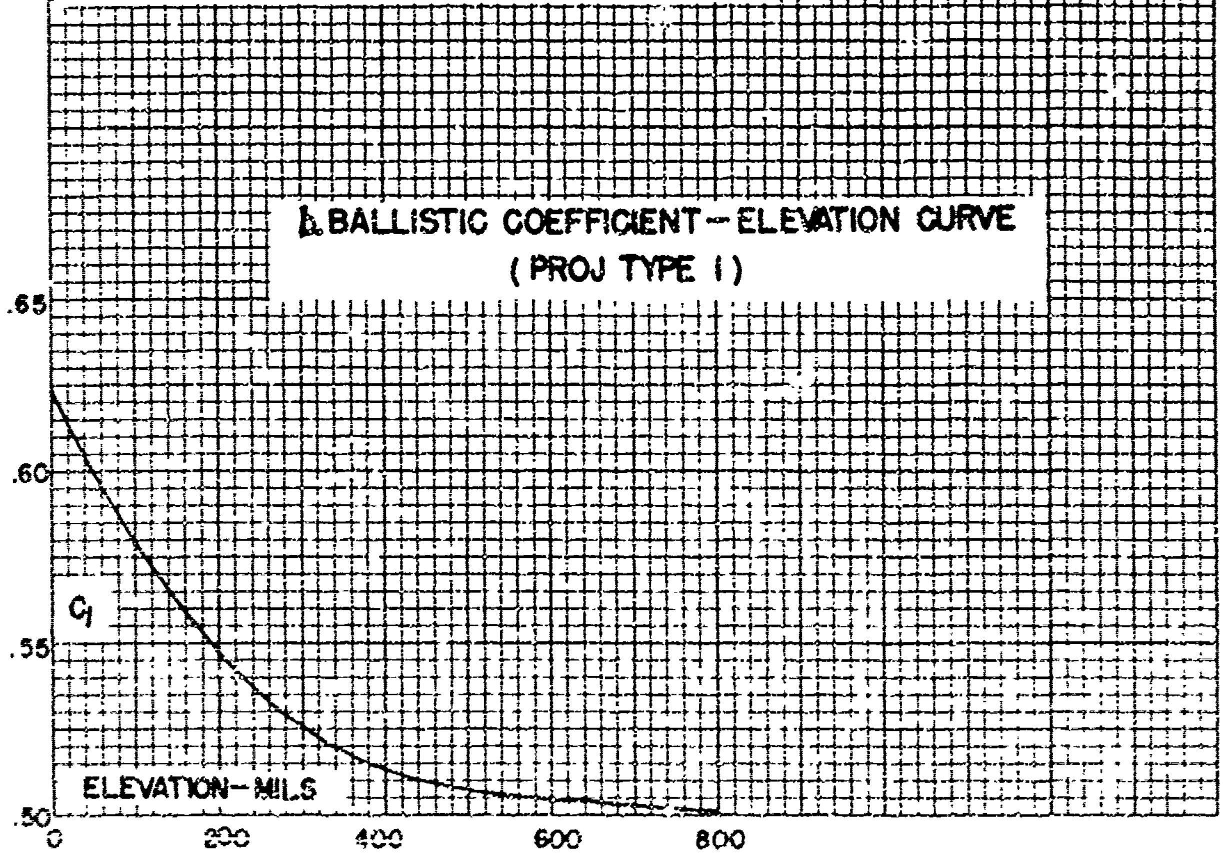
b. Stability. These data were obtained with the experimental Shell T22 with a PD Fuze; its physical characteristics are given in paragraph 4 (see Ballistic Research Laboratory Memorandum Reports No. 300 and 348D).

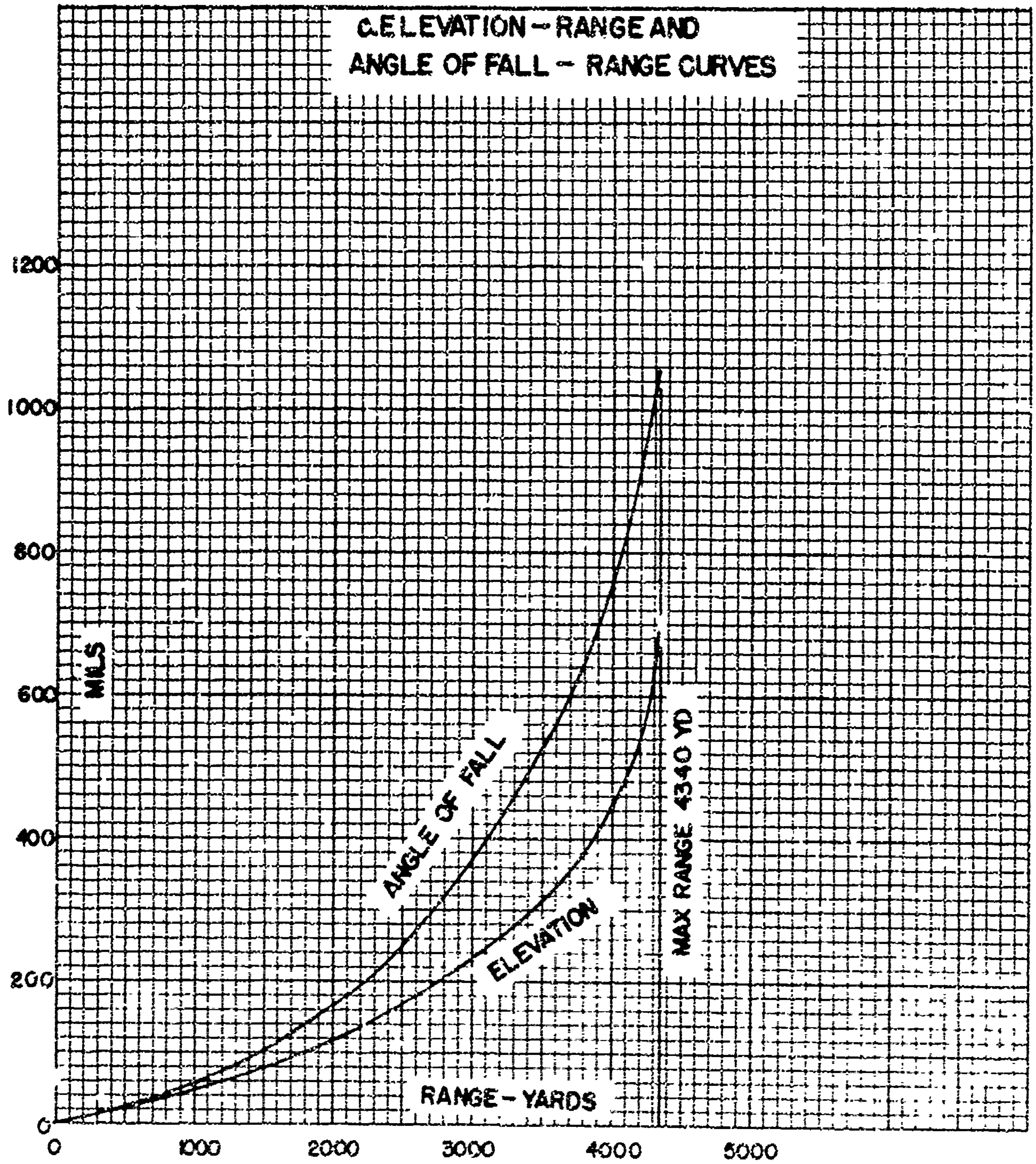
Muzzle velocity	1176 fps
Twist of rifling	1/30
Stability factor (standard)	1.82
Moment coefficient, K_M	1.31

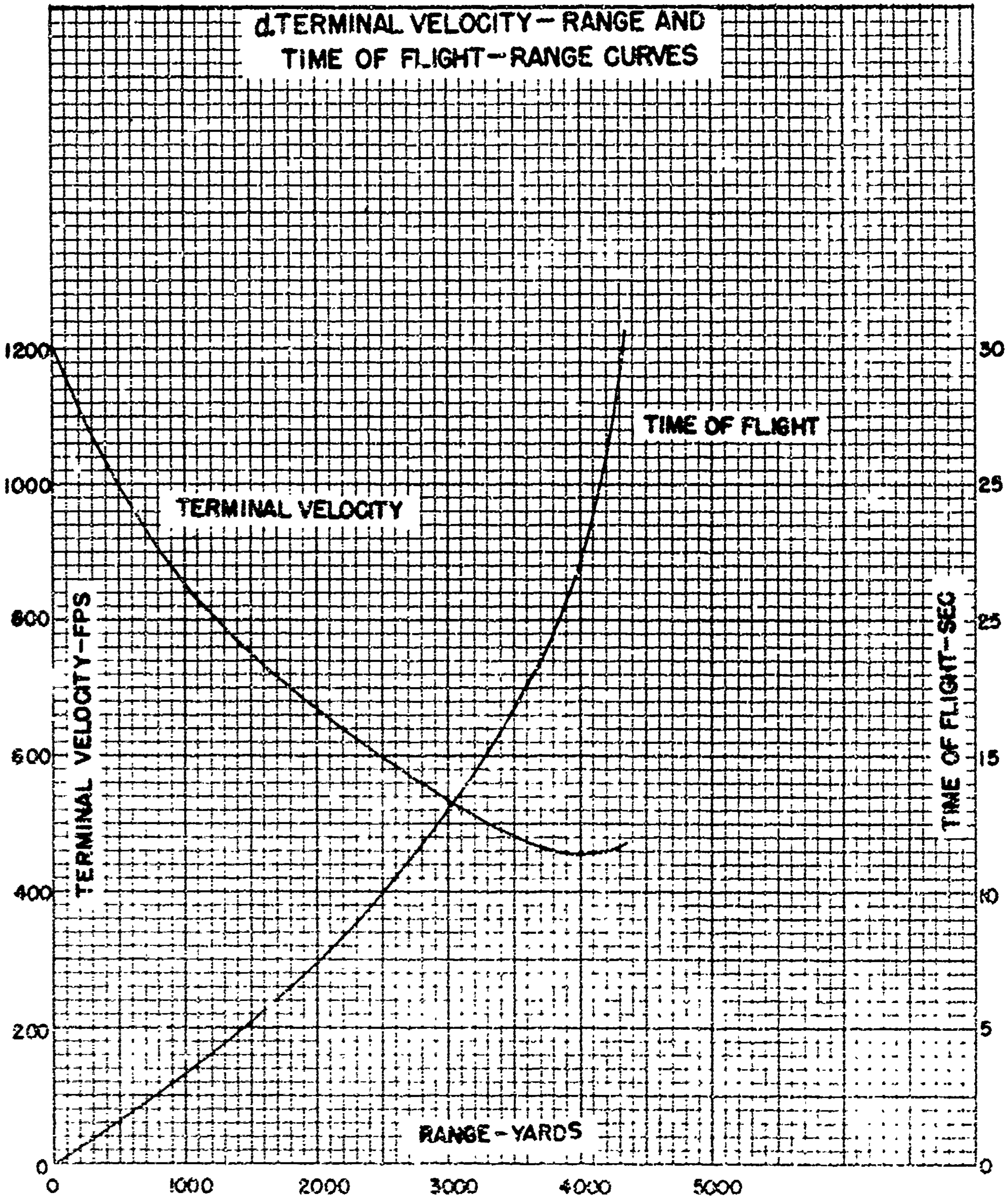
7. Firing table data. FT 57-E-1.

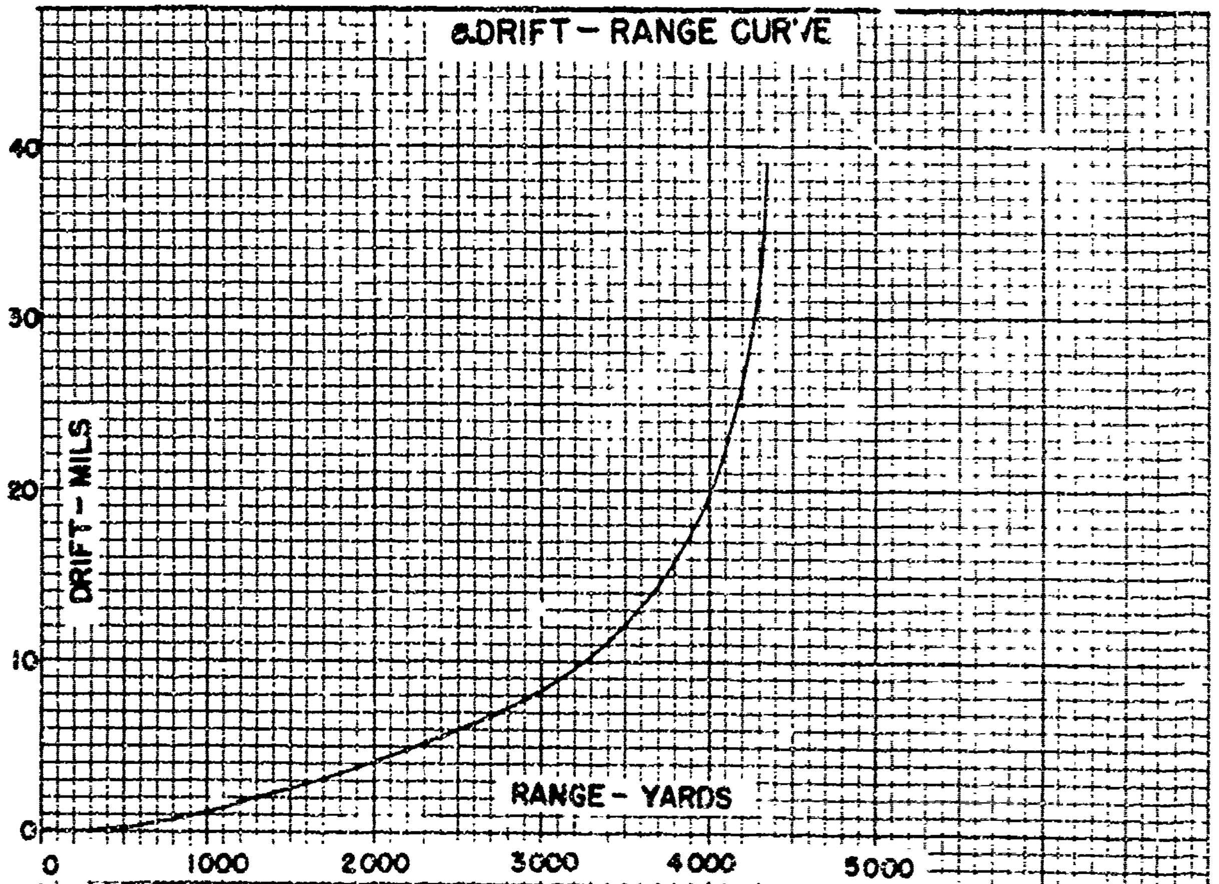
Rifle, 57-mm, M18. Twist of rifling: 1/30. Muzzle velocity: 1200 fps. OCM items 27443 and 28073 recommended and approved standardization of the HE Shell M306.


a. FORM FACTOR – ELEVATION CURVE
(PROJ TYPE I)

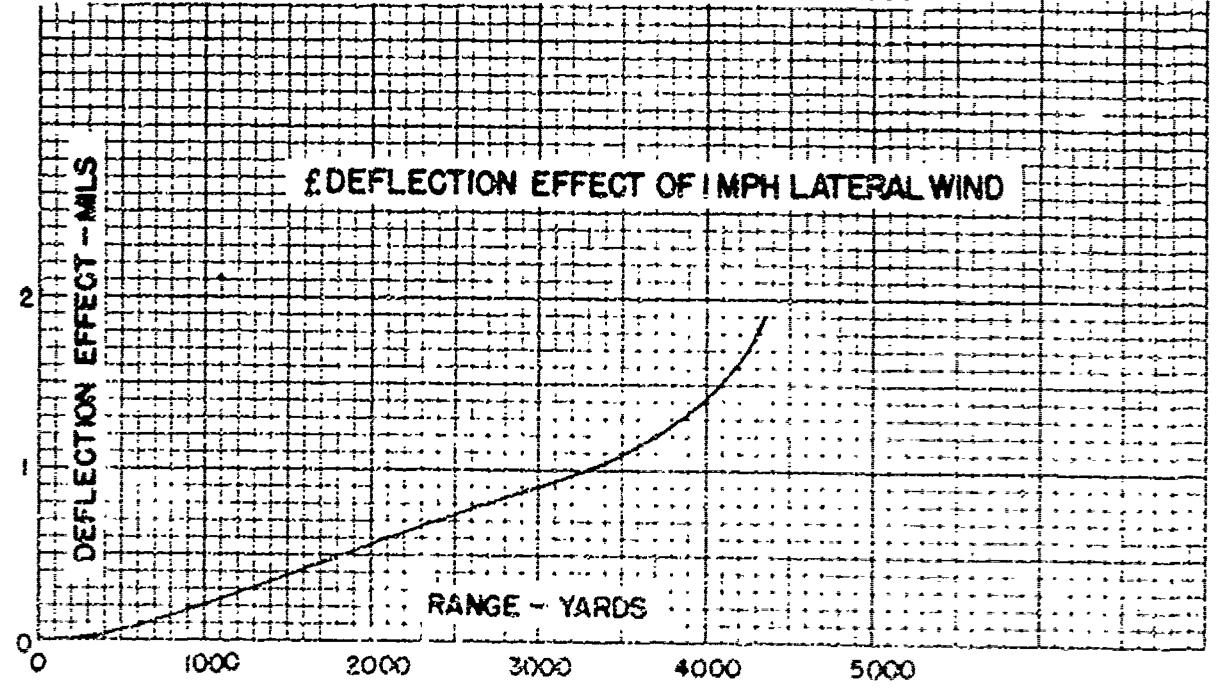

b. BALLISTIC COEFFICIENT – ELEVATION CURVE
(PROJ TYPE I)


Q.E. ELEVATION – RANGE AND
ANGLE OF FALL – RANGE CURVES
MILS
1200
1000
800
600
400
200
0
ANGLE OF FALL
ELEVATION
MAX RANGE 4340 YD
RANGE – YARDS
0
1000
2000
3000
4000
5000

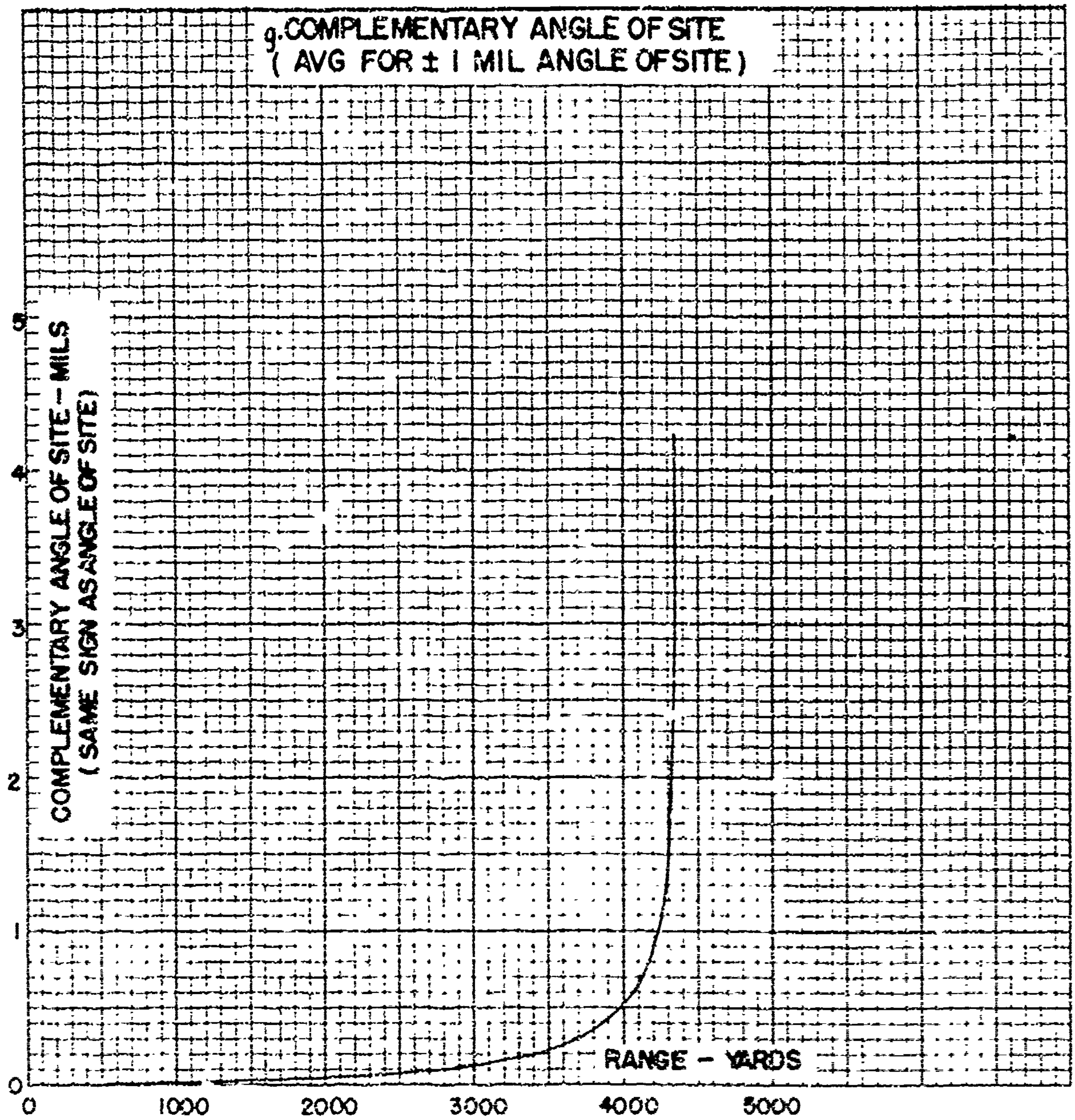

d.TERMINAL VELOCITY — RANGE AND
TIME OF FLIGHT — RANGE CURVES
TIME OF FLIGHT
TERMINAL VELOCITY
TERMINAL VELOCITY — FPS
TIME OF FLIGHT — SEC
RANGE — YARDS
1200
1000
800
600
400
200
0
30
25
25
15
10
5
0
0
1000
2000
3000
4000
5000

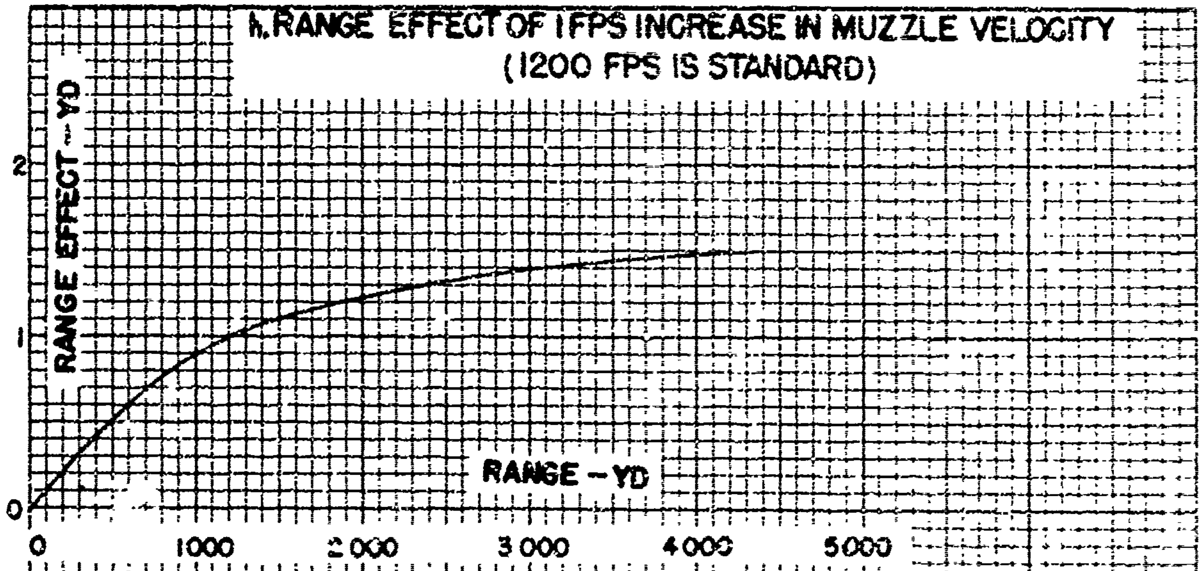


a. DRIFT — RANGE CURVE

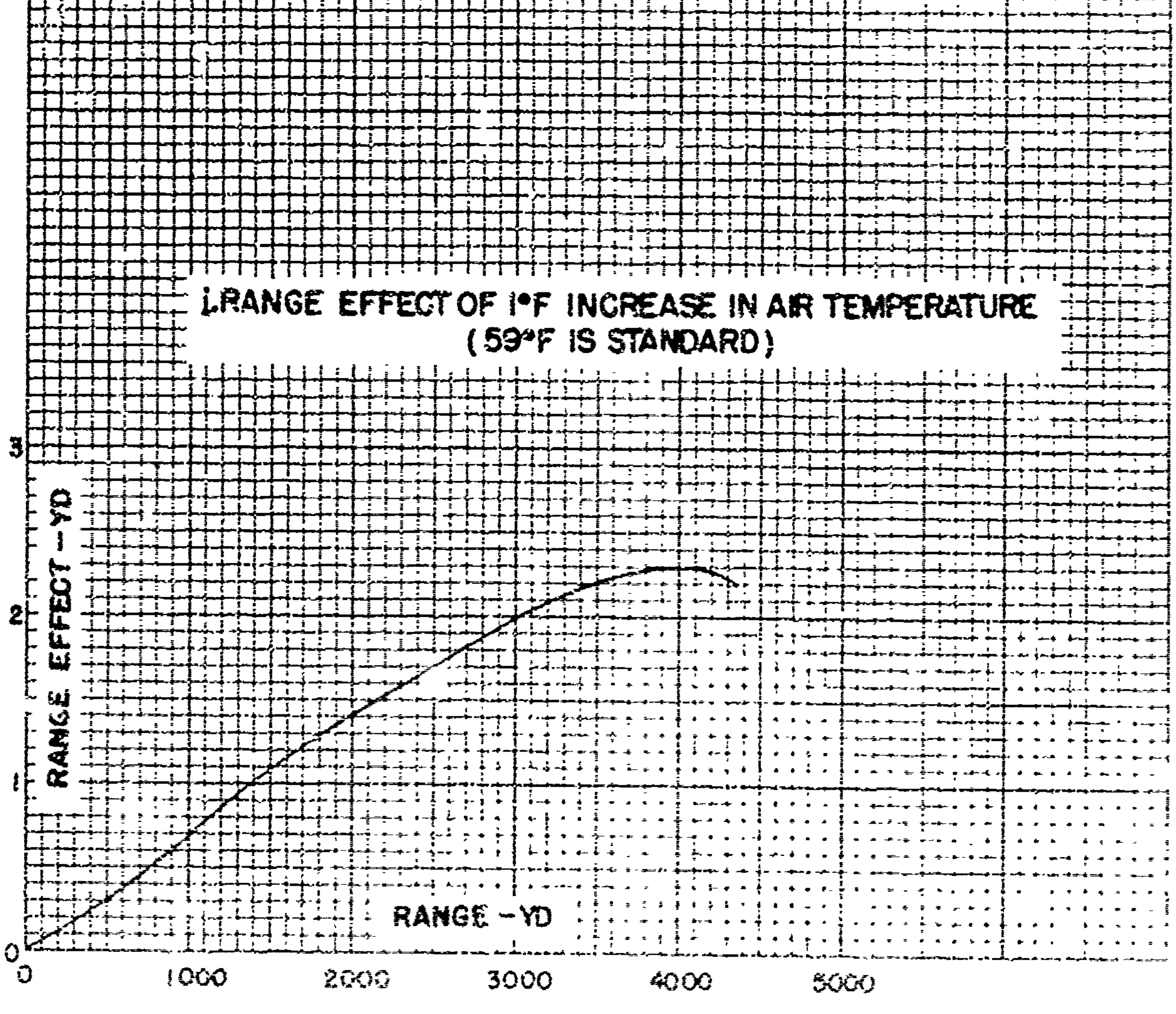


f. DEFLECTION EFFECT OF 1 MPH LATERAL WIND

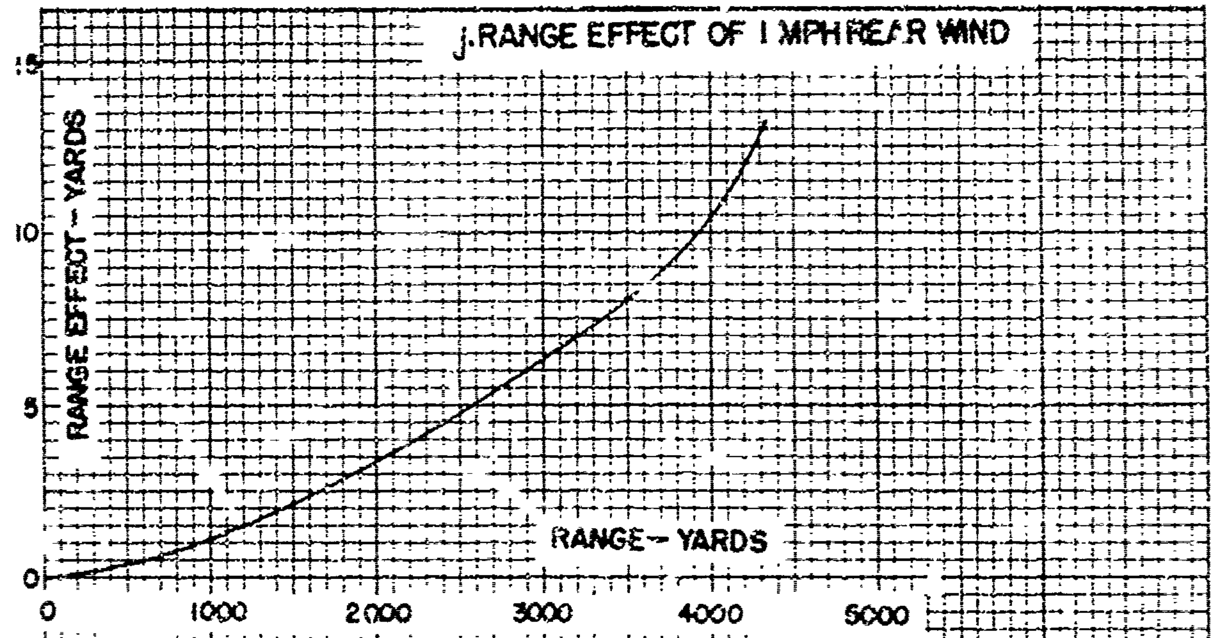

g. COMPLEMENTARY ANGLE OF SITE
(AVG FOR ± 1 MIL ANGLE OF SITE)
COMPLEMENTARY ANGLE OF SITE – MILS
(SAME SIGN AS ANGLE OF SITE)
RANGE – YARDS
0
1
2
3
4
5
0
1000
2000
3000
4000
5000



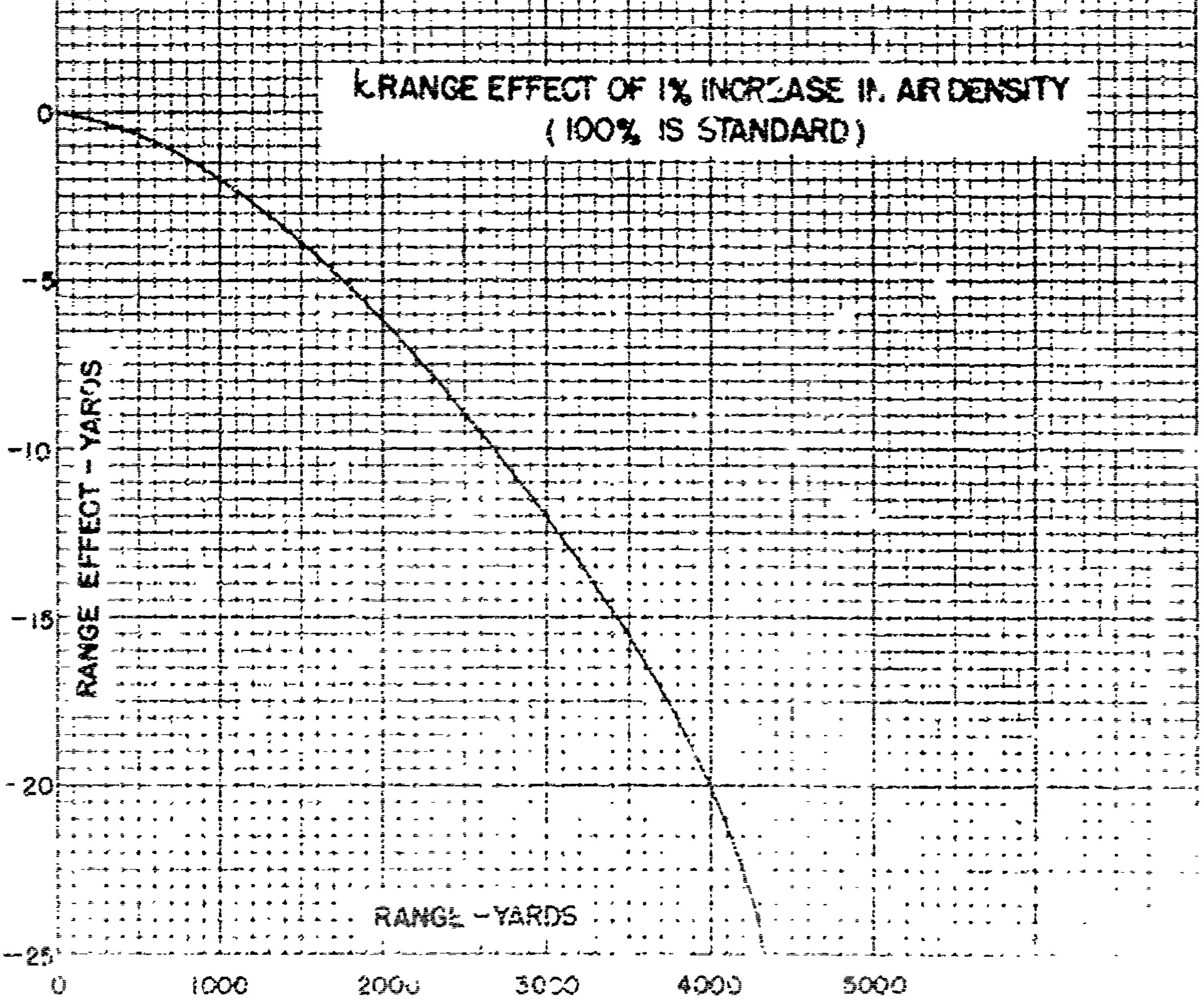
h. RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY (1200 FPS IS STANDARD)



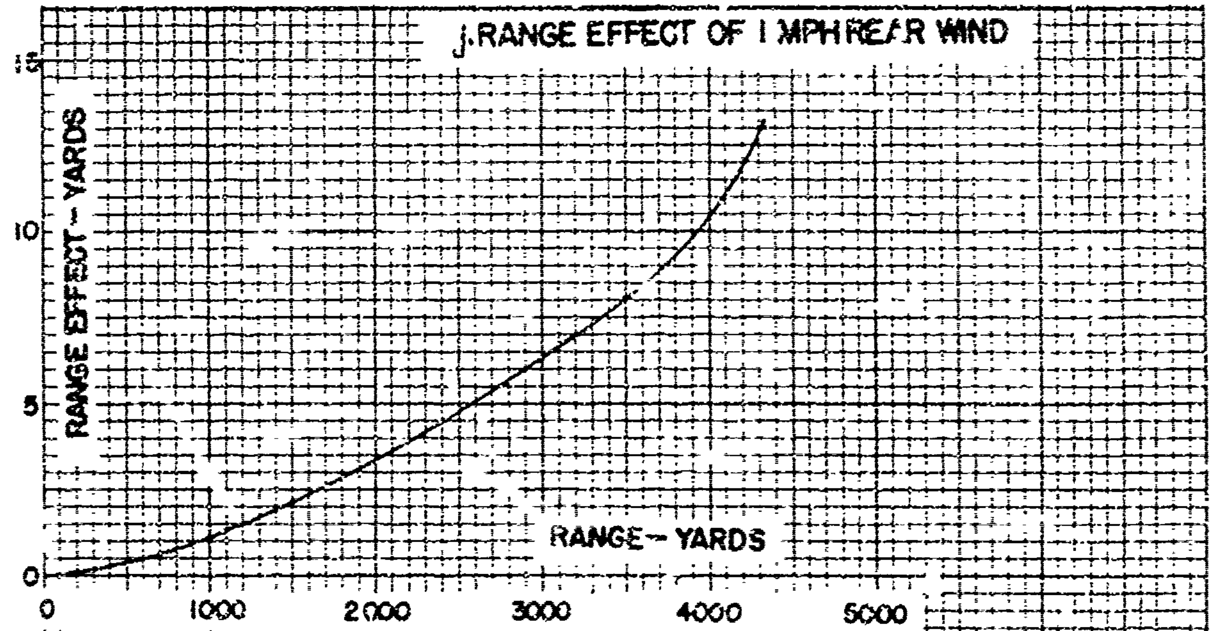
i. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE (59°F IS STANDARD)



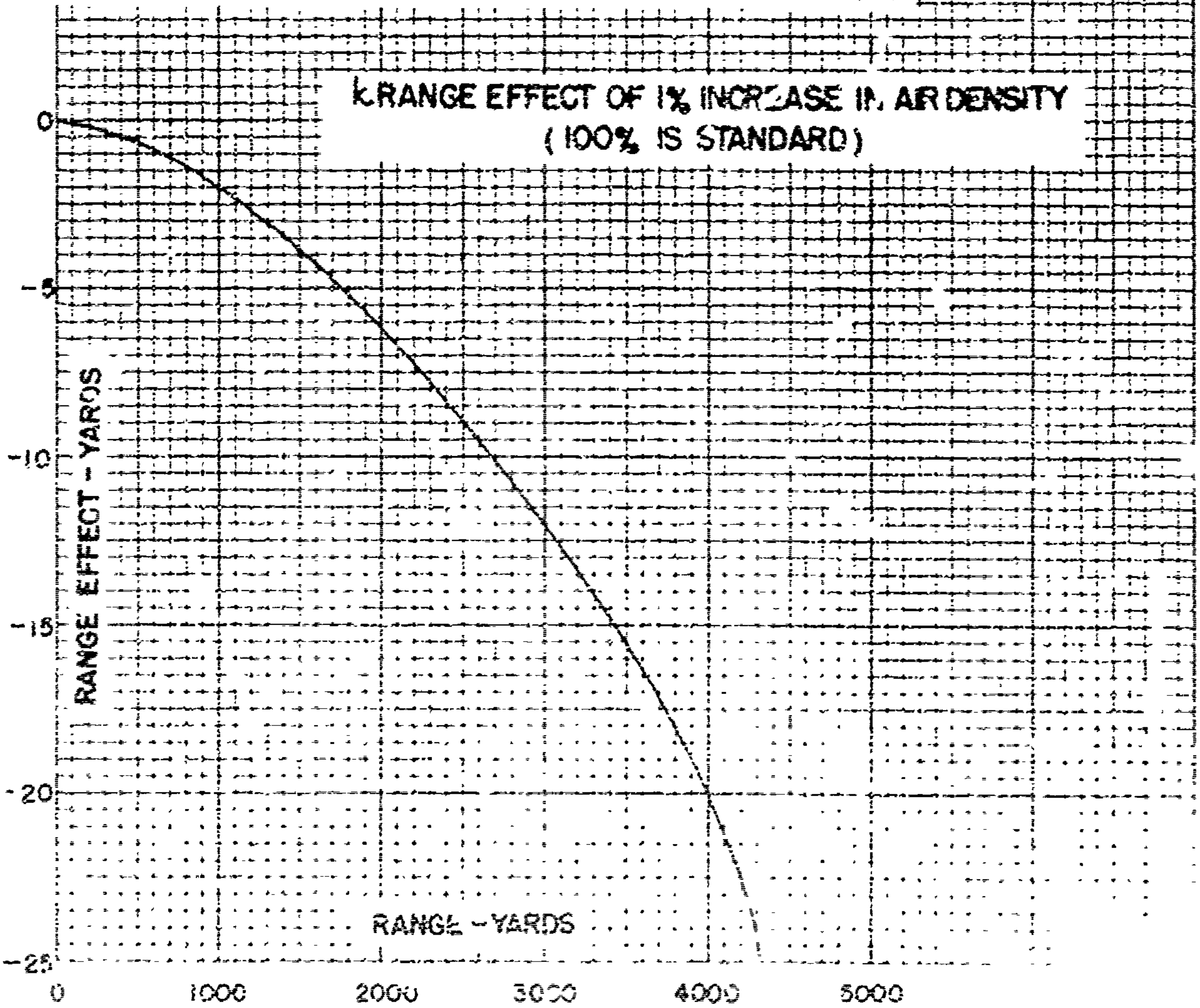
j. RANGE EFFECT OF 1 MPH REAR WIND



k. RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)



j. RANGE EFFECT OF 1 MPH REAR WIND



k. RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)

SECTION V

EFFECT DATA

	Paragraph
Sand pit fragmentation -	8
Panel fragmentation -	9

8. **Sand pit fragmentation.** The data given in this paragraph were extracted from Firing Record P-38375. Five HE Shell T22 were placed in boxes and detonated statically by means of an electric blasting cap connected to the PD Fuze T119E1, which was modified for this purpose. The fragments were separated from the sand by means of a magnet and grouped according to weight. The following table shows the average number and weight of the recovered fragments.

Weight zone (grains)	No. of Fragments	Weight (lb)	Percentage of Empty Shell
0 to 50	428	0.82	
50 to 75	16	0.13	
75 to 150	12	0.16	
150 to 750	1	0.03	
Total fragments	457	1.14	54
Scrap		0.35	17
Total fragments and scrap		1.49	71
Empty shell		2.11	100
Loaded shell		2.63	

9. **Panel fragmentation.** The data given in this paragraph were extracted from Firing Record P-38069. The panels consisted of 1-inch dressed No. 3 pine boards 9 feet high, placed in two semi-circles with radii of 15 and 30 feet. Each of five HE Shell T22 was placed at the common center of the semi-circles, with its axis in a horizontal plane that bisected the panels, and detonated statically by means of an electric blasting cap connected to the PD Fuze T119E1, which was modified for this purpose. Fragment velocities were obtained by means of screens placed 15 feet from the shell. The following table shows the average weight of shell, fragment velocity, and number of fragments that penetrated the panels.

Weight of shell		2.68 lb
Fragment velocity:	Side spray	4259 fps
	Nose spray	1332 fps

No. of fragments:	Perforations	Penetrations
15-ft radius	146	471
30-ft radius	67	197
Total	213	668

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 57-1-307

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
3 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HEAT, 57-mm, M307
with
Fuze, PI, M90

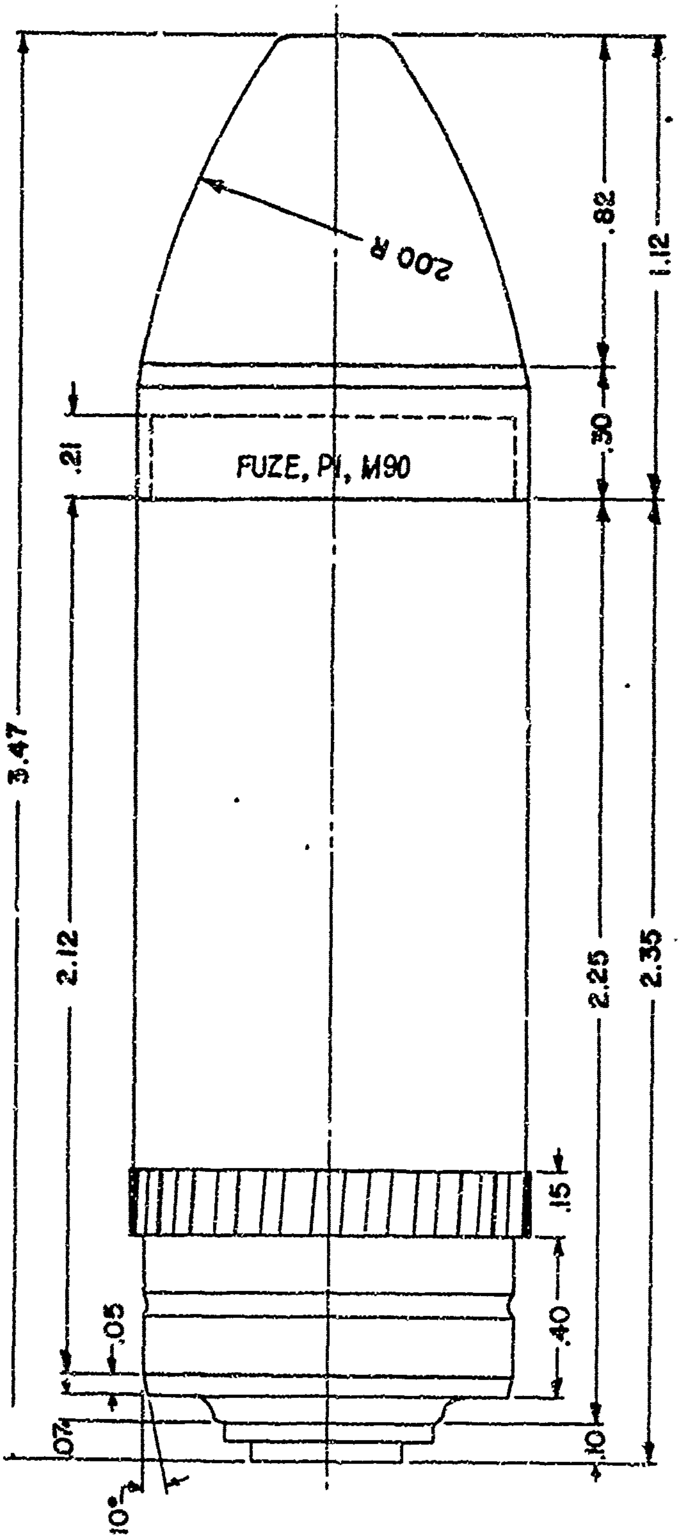
Section		Paragraphs
I	General - - - - - - - - - - -	1
II	Description - - - - - - - - -	2 - 4
III	Interior ballistic data - - - -	5
IV	Exterior ballistic data - - -	6 - 7
V	Effect data - - - - - - - - - -	8

SECTION I

GENERAL

	Paragraph
Purpose -	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 57-mm High Explosive Antitank Shell M307 with the Point Initiating Fuze M90. This information is collected from the drawings, reports, and firing ·les pertaining to this ammunition.



ALL DIMENSIONS IN CALIBERS
1 CAL = 2.244"

SHELL, HEAT, 57-MM, M307
FUZE, PI, M90

SECTION II

DESCRIPTION

Paragraph

Drawings - 2
Dimensions - 3
Physical characteristics - 4

2. Drawings.

Shell:	Metal parts assembly and details	75-2-353
	Details	75-2-354
Fuze:	Assembly	73-2-226
	Details	73-2-237 and 238

3. Dimensions.

Closing plug:	Length (outside)	0.10 cal
Shell body:	Base to band	0.40 cal
	Band width	0.15 cal
	Base extension	0.07 cal
	Chamfer angle	10°
	Cylindrical length	2.12 cal
	Threaded length (under fuze)	0.21 cal
	Total body length	2.35 cal
Fuze:	Body length (outside)	0.30 cal
	Ogive length	0.82 cal
	Radius of ogival arc	2.00 cal
	Total length	1.12 cal
Length:	Shell (body and closing plug)	2.35 cal
	Shell and fuze	3.47 cal

4. Physical characteristics.

Shell		Weight	CG to	Moments of Inertia - lb. in^2	
Lot No.	Dwg 75-2-353 Rev - Date	lb	Base cal	Axial	Transverse
PA-E-T45-187	-- 24 Oct 44	2.71	1.353	2.20	10.42
MG-1	1 - 3 Mar 45	2.70	1.269	2.086	9.756
GR-2X	2 - 8 May 45	2.75	(Standard)		

SECTION III

INTERIOR BALLISTIC DATA

Paragraph
Theoretical yaw in bore - 5

5. Theoretical yaw in bore.

Minimum	5.3 min
Maximum	9.0 min

SECTION IV

EXTERIOR BALLISTIC DATA

Paragraph
Aerodynamic data - 6
Firing table data - 7

6. Aerodynamic data.

a. Drag. The form factors relative to Projectile Type 1 that are tabulated here were determined from observed times of flight.

Shell Lot No.	Form Factor i_1	Velocity fps Muzzle	Velocity fps Mean	Drag Coefficient K_D (at muzzle vel.)
MG-1	0.982	1200	956	.218
GR-2X	1.05	1200	1023	.233

b. Stability. Ballistic Research Laboratory Memorandum Report No. 346D and letter APG 474.1/165 give the stability factors and moment coefficients of two lots of shell whose interior dimensions were different (see par. 4 for their physical characteristics).

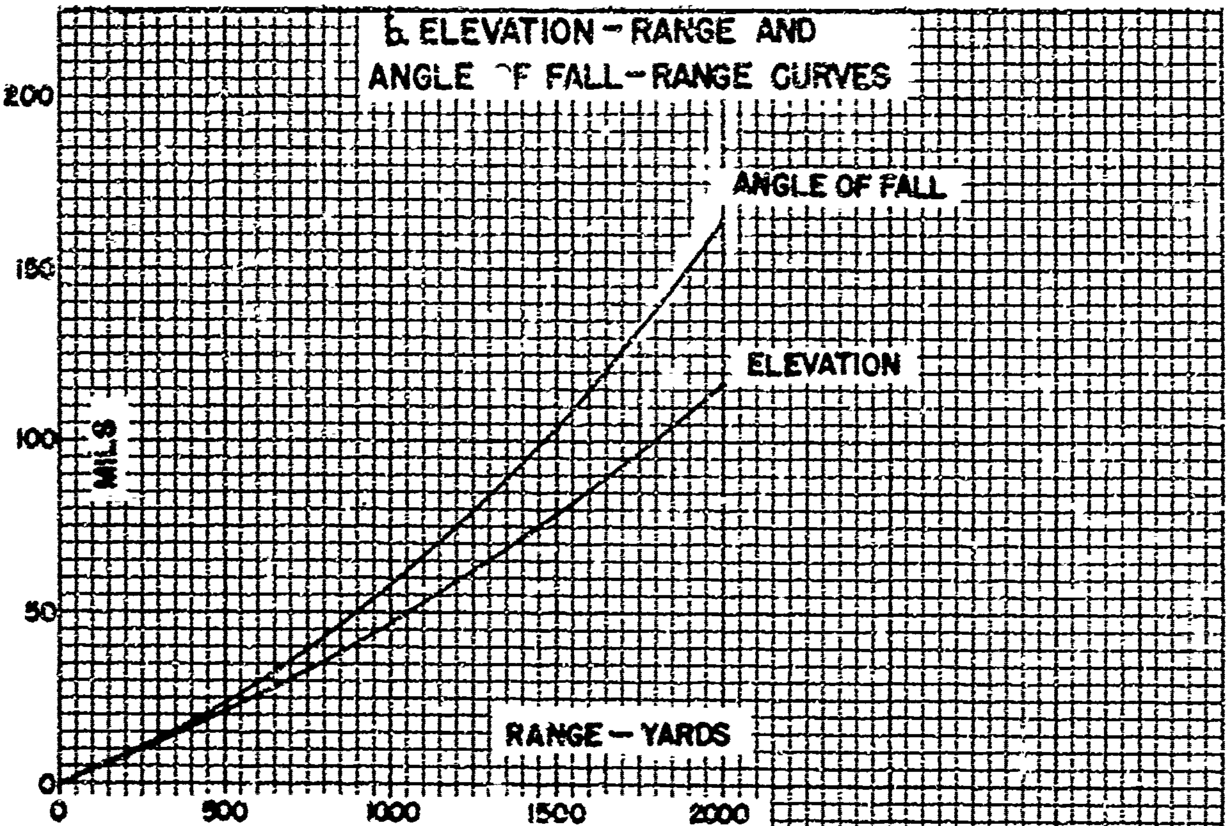
Shell Lot No.	Muzzle Velocity fps	Twist of Rifling 1/n	Stability Factor s	Moment Coefficient K_M
PA-E-T45-187	1200	1/30	1.34	1.53
MG-1	1215	1/30	1.75	1.15

7. Firing table data. FT 57-E-2 (abridged).

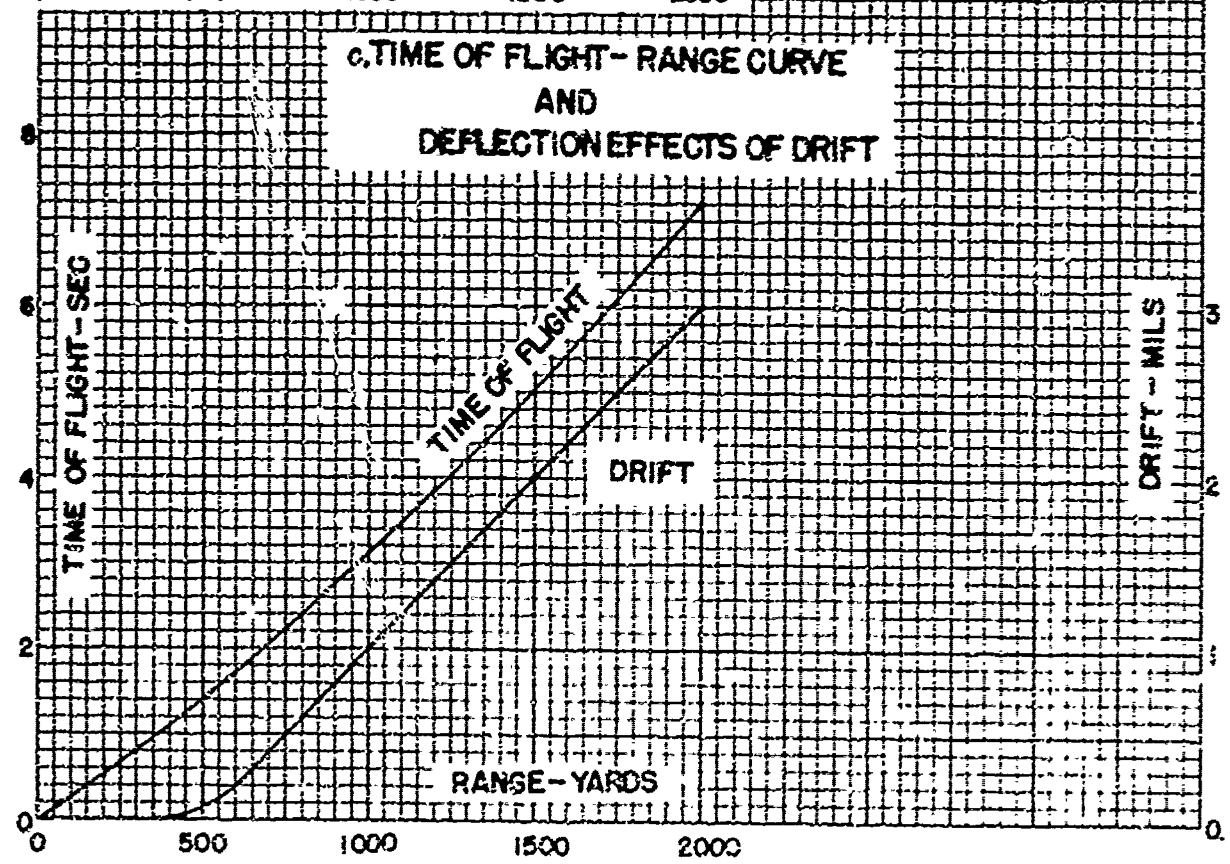
Rifle, 57-mm, M18. Twist of rifling: 1/30. Muzzle velocity: 1200 fps. OCM items 27443 and 28073 recommended and approved standardization of the HEAT Shell M307.

a. Form factor and ballistic coefficient. The following form factor and ballistic coefficient relative to Projectile Type 1 apply to all elevations.

i_1	0.94
C_1	0.583



b. ELEVATION – RANGE AND ANGLE OF FALL – RANGE CURVES



c. TIME OF FLIGHT – RANGE CURVE AND DEFLECTION EFFECTS OF DRIFT

SECTION V

EFFECT DATA

Paragraph
Penetration - 8

8. **Penetration.** The average penetration of homogeneous armor plate by 57-mm HEAT Shell M307 is 2.5 inches.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 60-1-49

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
3 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 60-mm, M49A2
with
Fuze, PD, M52A1

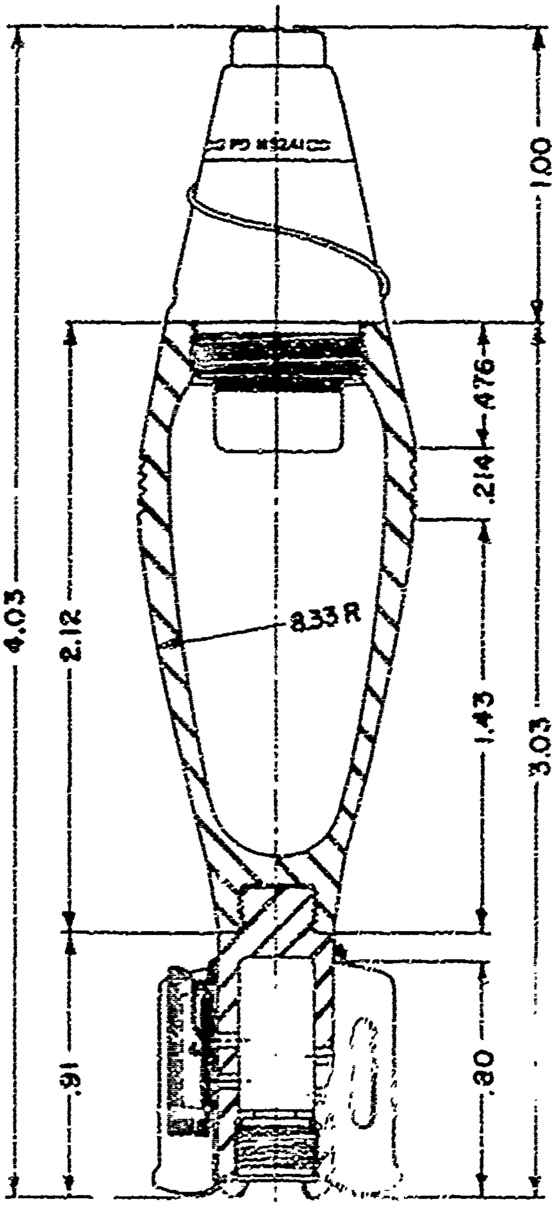
Section		Paragraph
I	General - - - - - - - - - - - - -	1
II	Description - - - - - - - - - - -	2 - 4
III	Exterior ballistic data - - - - -	5 - 6

SECTION I

GENERAL

	Paragraph
Purpose -	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics and ballistics of the 60-mm High Explosive Shell M49A2 with the Point Detonating Fuze M52A1. This information is collected from the drawings, reports and firing tables pertaining to this ammunition.



SHELL., HE, 60-MM, M49A2
FUZE, PD, M52A1

SECTION II

DESCRIPTION

Paragraph

Drawings - 2
Dimensions - 3
Physical characteristics - 4

2. Drawings.

Shell: Metal parts shipping assembly and details	75-2-288
Fins: Assembly and details	75-2-285
Fuze: Assembly and details	73-1-161
Complete round: Assembly and marking diagram	75-1-82

3. Dimensions.

Fins: Number	6
Length	0.89 cal
Length of assembly (outside)	0.91 cal
Shell: Radius of arc behind bourrelet	8.33 cal
Length of rear part	1.43 cal
Length of bourrelet	0.21 cal
Length of front part	0.48 cal
Total length	2.12 cal
Fuze: Length (outside)	1.00 cal
Length: Shell and fin assembly	3.03 cal
Shell, fin assembly, and fuze	4.03 cal

4. Physical characteristics.

Weight (standard)	3.065 lb
Center of gravity to nose	1.965 cal
Transverse moment of inertia	13.43 lb in^2

SECTION III

EXTERIOR BALLISTIC DATA

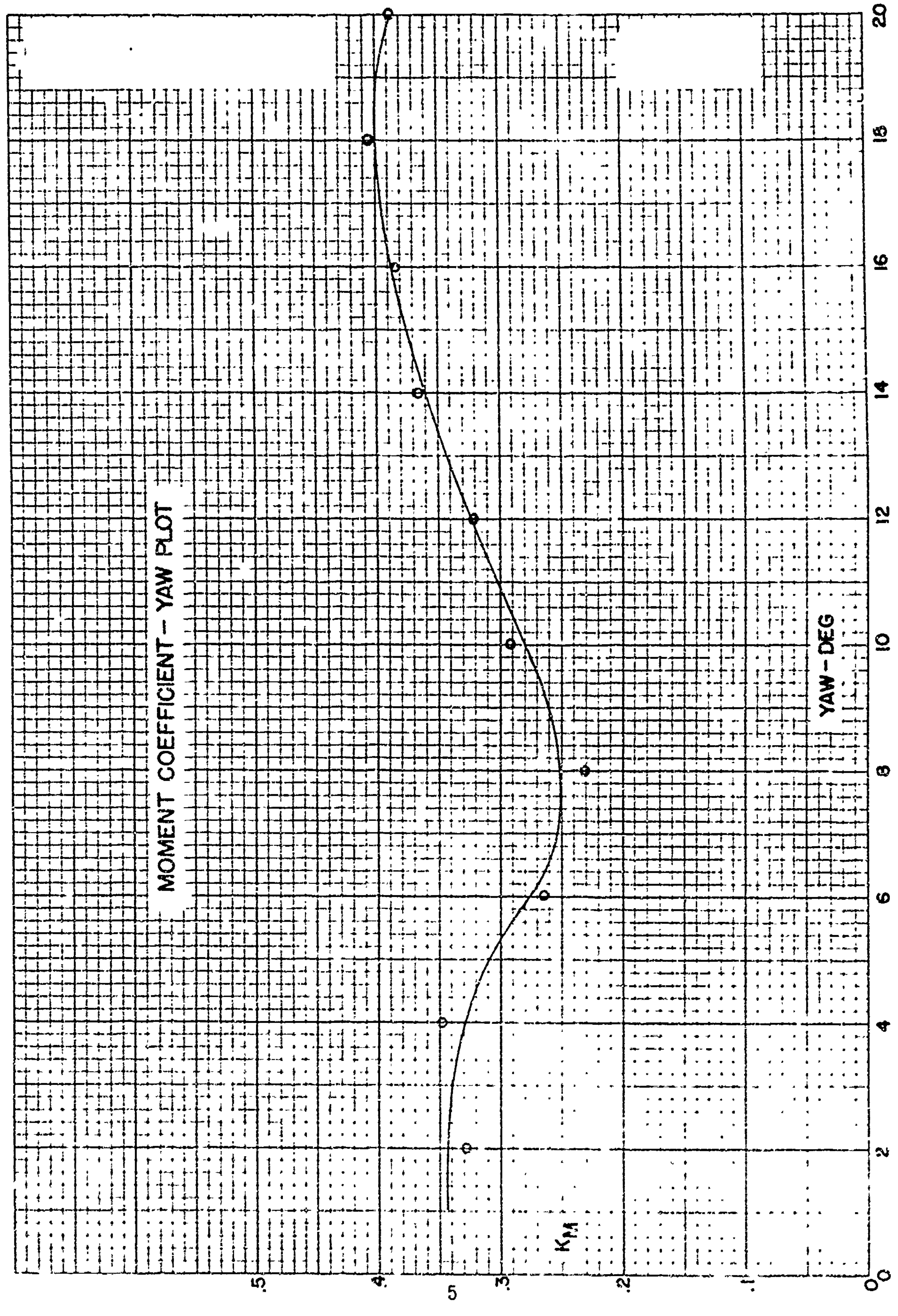
Paragraph
Aerodynamic data - 5
Firing table data - 6

5. Aerodynamic data.

a. **Drag coefficients.** The following values were determined from the form factors given in paragraph 6a.

Muzzle Velocity fps	Drag Coefficient K_D
169	.058
292	.065
377	.067
449	.067
518	.068

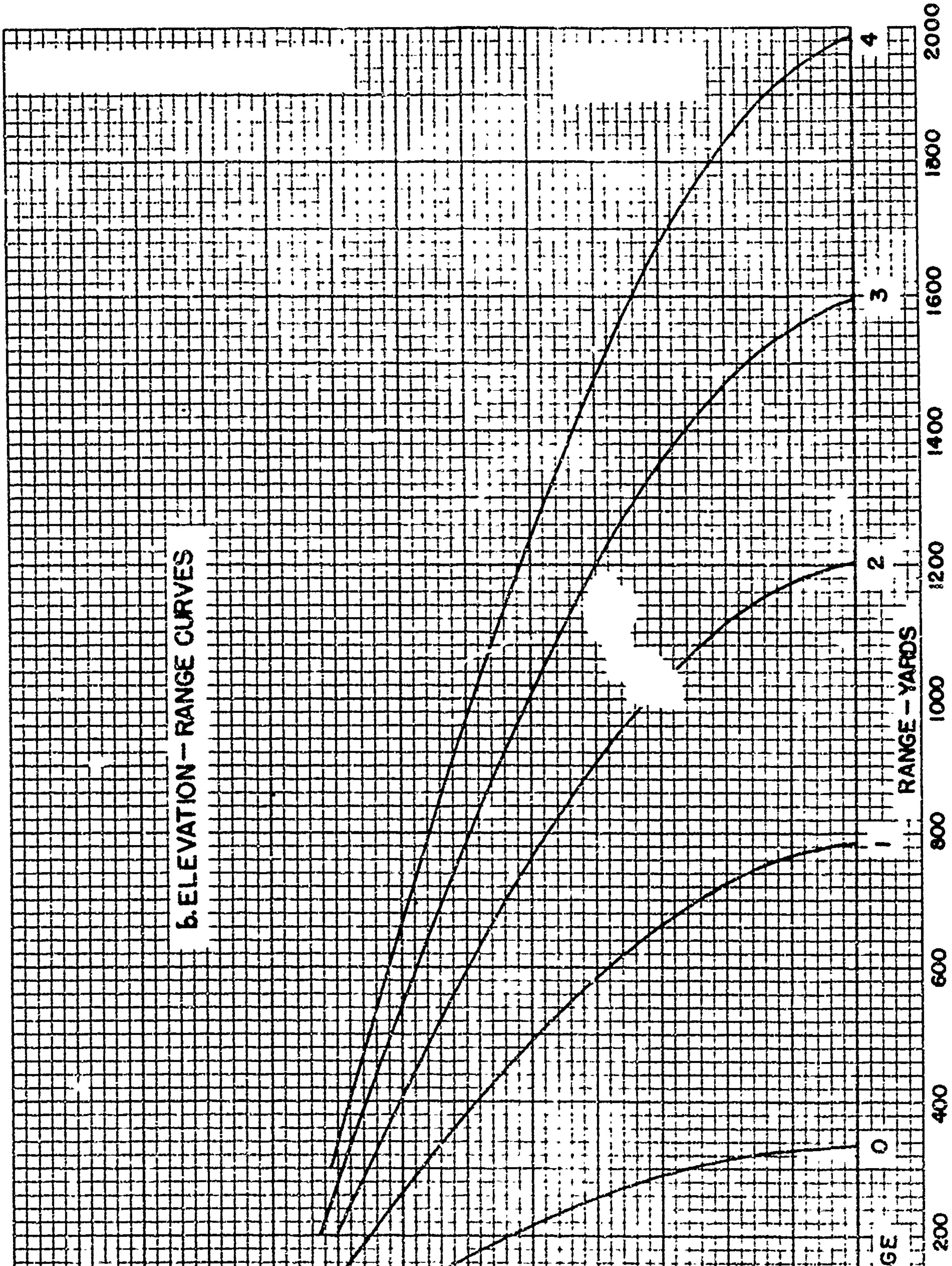
b. **Moment coefficients.** Ballistic Research Laboratory Report No. 326, "Aerodynamics of the 60-mm Shell M49A2 with Fuze M52", gives the moment coefficients which have been determined for this projectile. The value of K_M calculated from the observed nutational period of the shell with a maximum yaw of about 15° at a muzzle velocity of 225 fps is 0.034. The values computed from the torques measured by the Bureau of Standards in a wind tunnel at a velocity of 100 fps are shown on the following p...


MOMENT COEFFICIENT – YAW PLOT
YAW – DEG
K_M
0
2
4
6
8
10
12
14
16
18
20
0
.1
.2
.3
.4
.5
5

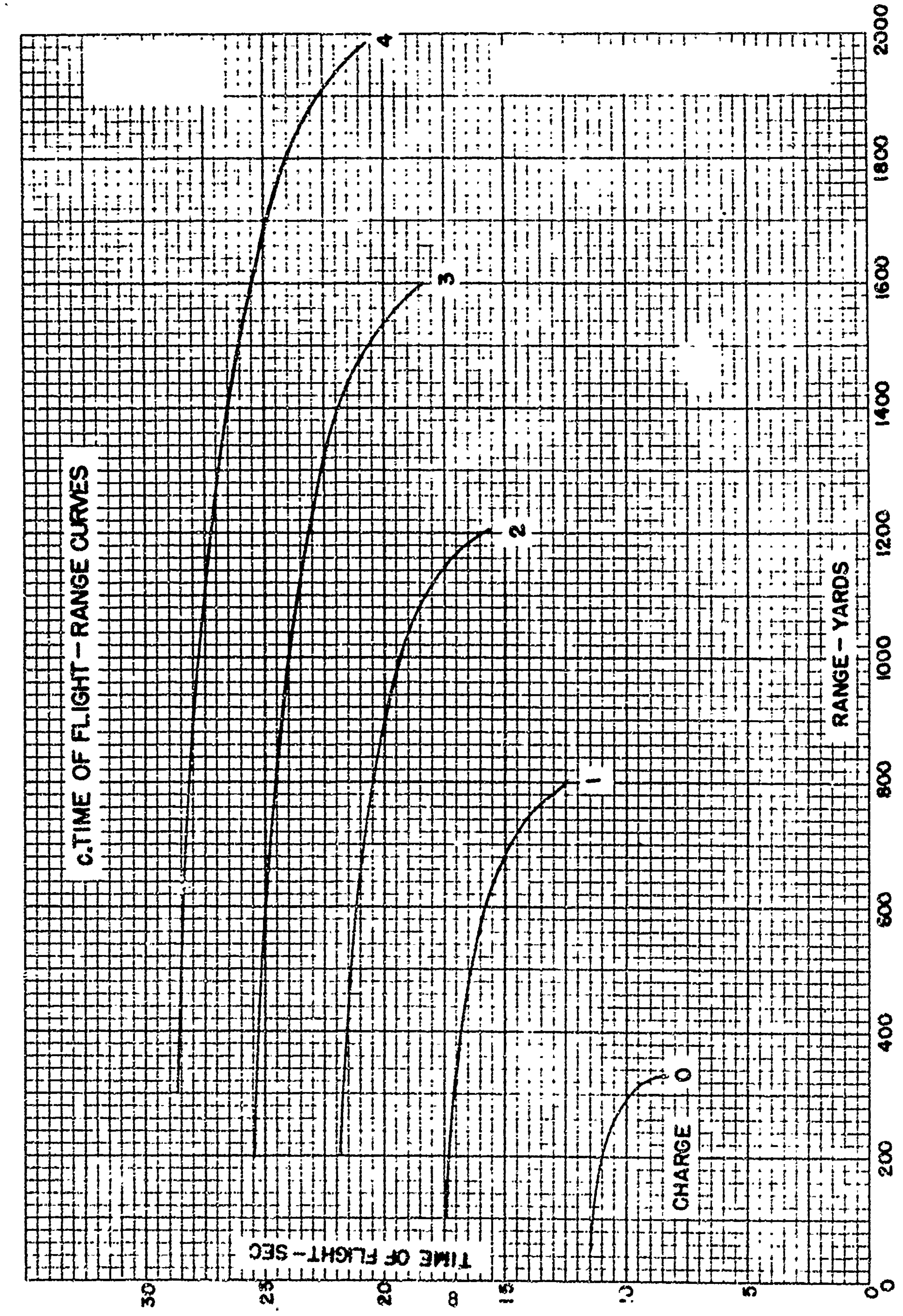
6. **Firing table ta.** FT 60-A-3 and FT 60-A-4 (abridged). Mortar, 60-mm, M2 and M19. Smooth bore. Muzzle loading. Projectile weight: 2.96 lb. OCM items 14517 and 14617 recommended and approved standardization of the HE Shell M49 with the PD Fuze M49. OCM item 15196 classified the HE Shell M49A1 (steel instead of cast iron) with the PD Fuze M52 as standard for limited procurement. OCM items 16026 and 16122 recommended and approved standardization of the HE Shell M49A2.

a. **Form factors and ballistic coefficients.** The following form factors and ballistic coefficients relative to Projectile Type 1 apply to all elevations.

Charge No.	Muzzle Velocity fps	Form Factor i_1	Ballistic Coefficient C_1
0	189	.62	.850
1	292	.73	.730
2	377	.78	.680
3	449	.81	.658
4	516	.82	.650



b. ELEVATION — RANGE CURVES



c. TIME OF FLIGHT — RANGE CURVES

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 60-1-83

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
4 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, Illuminating, 60-mm, M83A1
with
Fuze, Time, M65A1

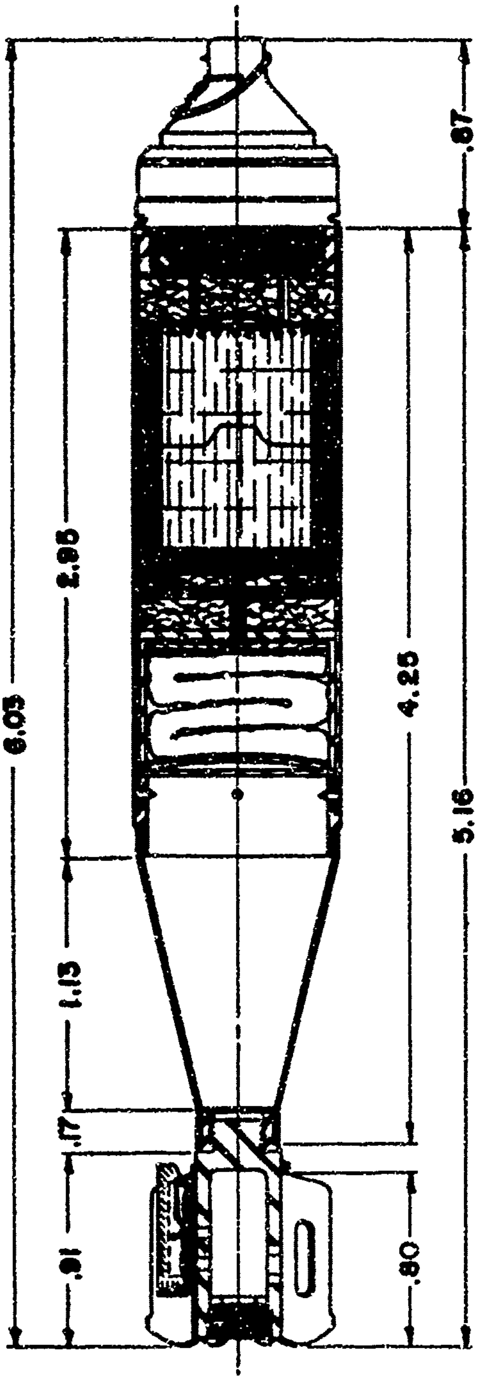
Section		Paragraph
I	General - - - - - - - - - -	1
II	Description - - - - - - - -	2 - 4
III	Exterior ballistic data - -	5 - 6
IV	Effect data- - - - - - - - -	7

SECTION I

GENERAL

	Paragraph
Purpose -	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 60-mm Illuminating Shell M83A1 with the Time Fuze M65A1. This information is collected from the drawings, reports, firing table and firing records pertaining to this ammunition.



ALL DIMENSIONS IN CALIBERS
1 CAL. = 2.362"

SHELL, ILLUMINATING, 60-MM, M83A1
FUZE, TIME, M65A1

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell:	Body and loading assembly	75-14-350
	Details	75-2-316
Fins:	Assembly and details	75-2-285
Fuze:	Assembly	73-3-177
	Details	73-3-178,179 and 180
Complete round:	Assembly and marking diagram	75-1-143

3. Dimensions.

Fins:	Number	8
	Length	0.80 cal
	Length of assembly (outside)	0.91 cal
Body:	Rear cylindrical part	0.17 cal
	Conical part	1.13 cal
	Front cylindrical part	2.95 cal
	Total length	4.25 cal
Fuze:	Length (outside)	0.87 cal
Length:	Body and fin assembly	5.16 cal
	Body, fin assembly, and fuze	6.03 cal

4. Physical characteristics.

Weight (standard)	3.77 lb

SECTION III

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data -	5
Firing table data -	6

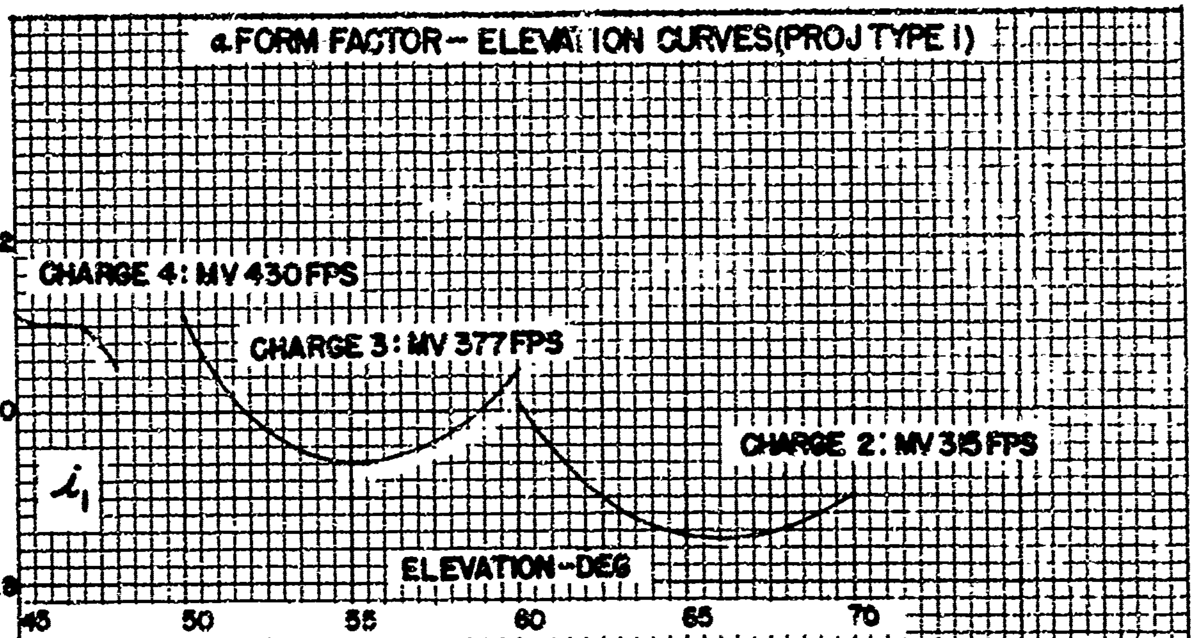
5. Aerodynamic data. The ballistic coefficient of a 3.7-lb Illuminating Shell M8[illegible] [illegible]tive to Projectile Type 1, determined at the lowest elevation used in the range firings with each propelling charge, and the corresponding form factor and drag coefficient are tabulated below.

Muzzle Velocity fps	Elevation deg	Ballistic Coefficient C_1	Form Factor i_1	Drag Coefficient K_D
315	60	.343	2.01	.177
377	50	.327	2.11	.180
430	45	.328	2.12	.176

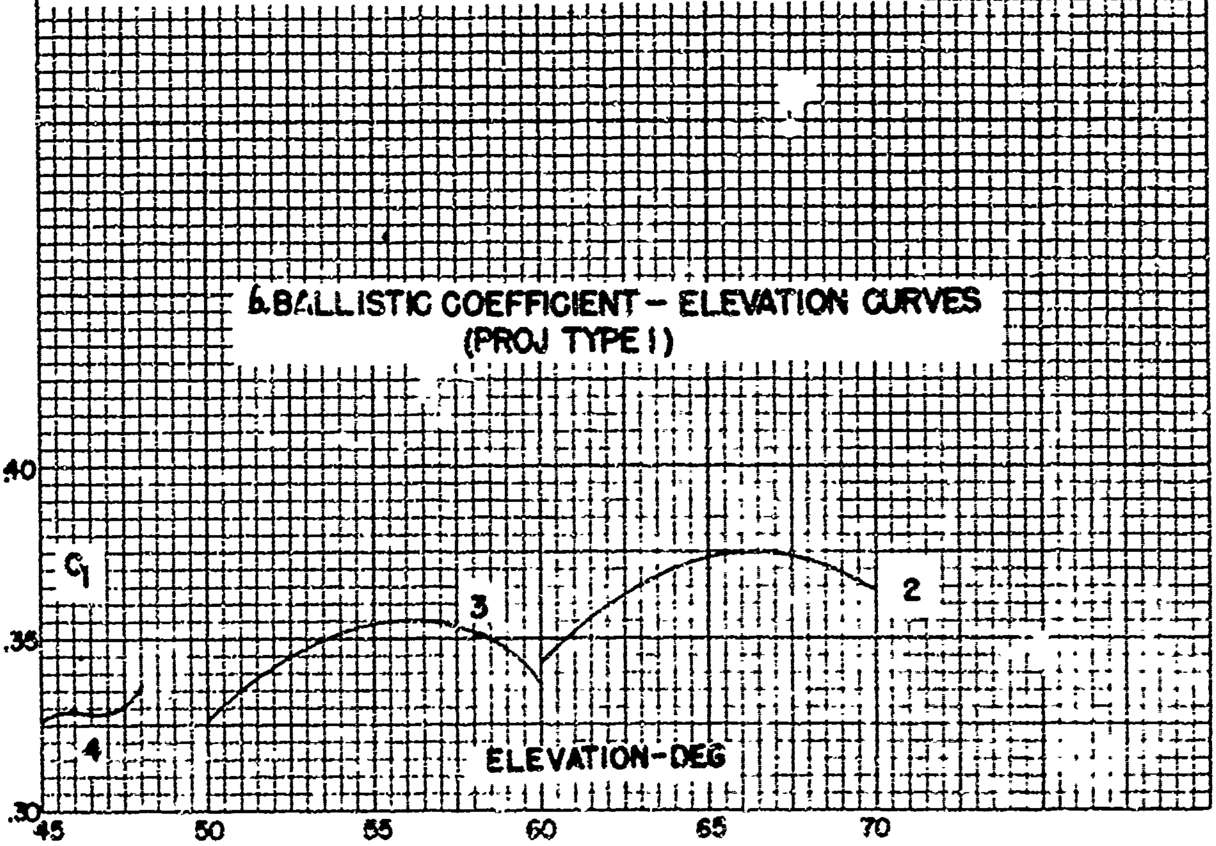
6. Firing table data. FT 60-G-1 (abridged)

Mortar, 60-mm, M2 and M19. Smooth bore. Muzzle loading. Projectile weight: 3.70 lb. OCM items 18031 and 18110 recommended and approved standardization of the Illuminating Shell M83 (propelled by 4 increments of M4 powder) with Time Fuze M65, which burns for about 15 sec.

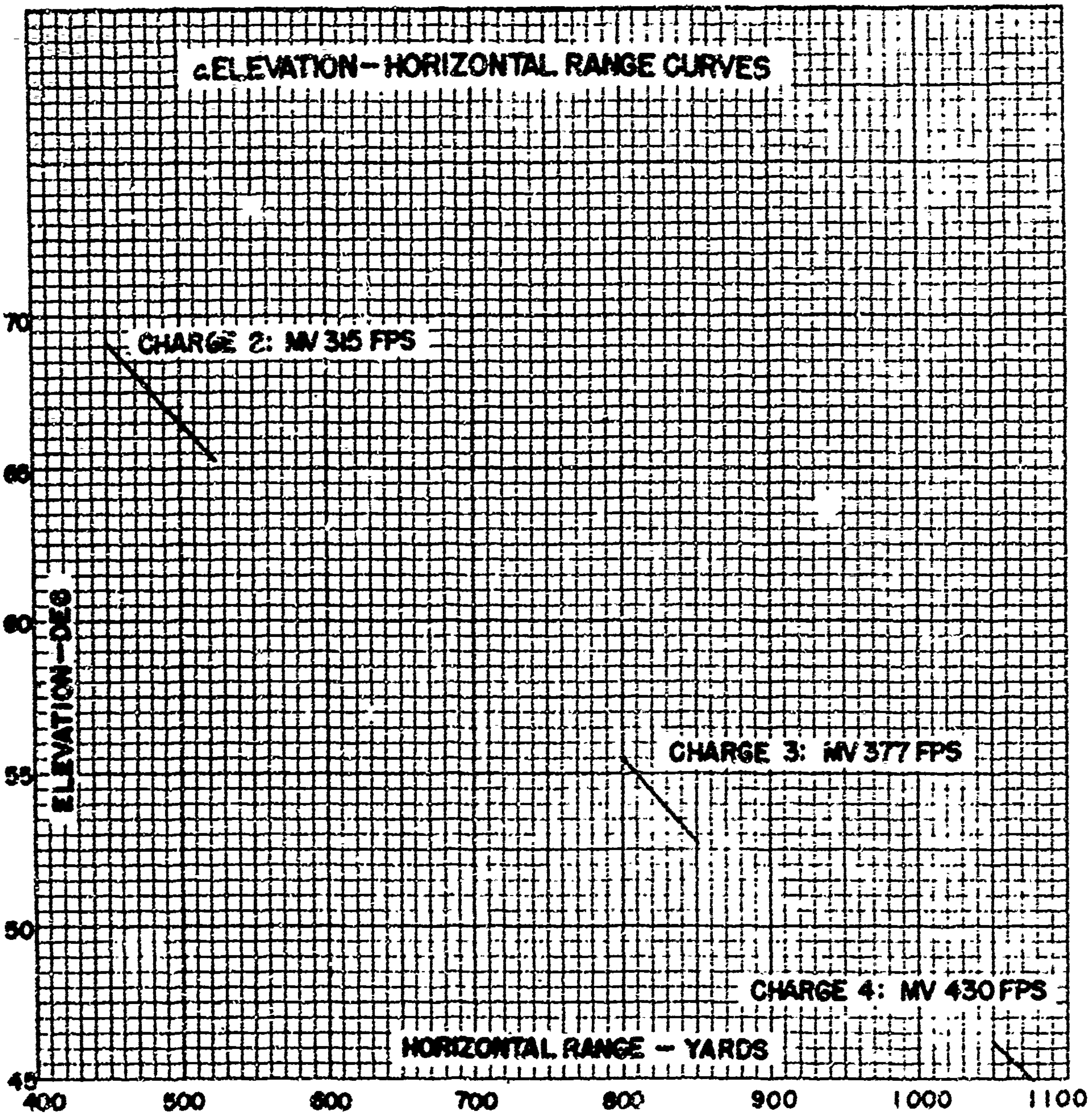
OCM item 23018 designated this projectile the Illuminating Shell M83A1 when propelled by 4 increments of M3 powder. OCM item 31590 reclassified these projectiles as limited standard.

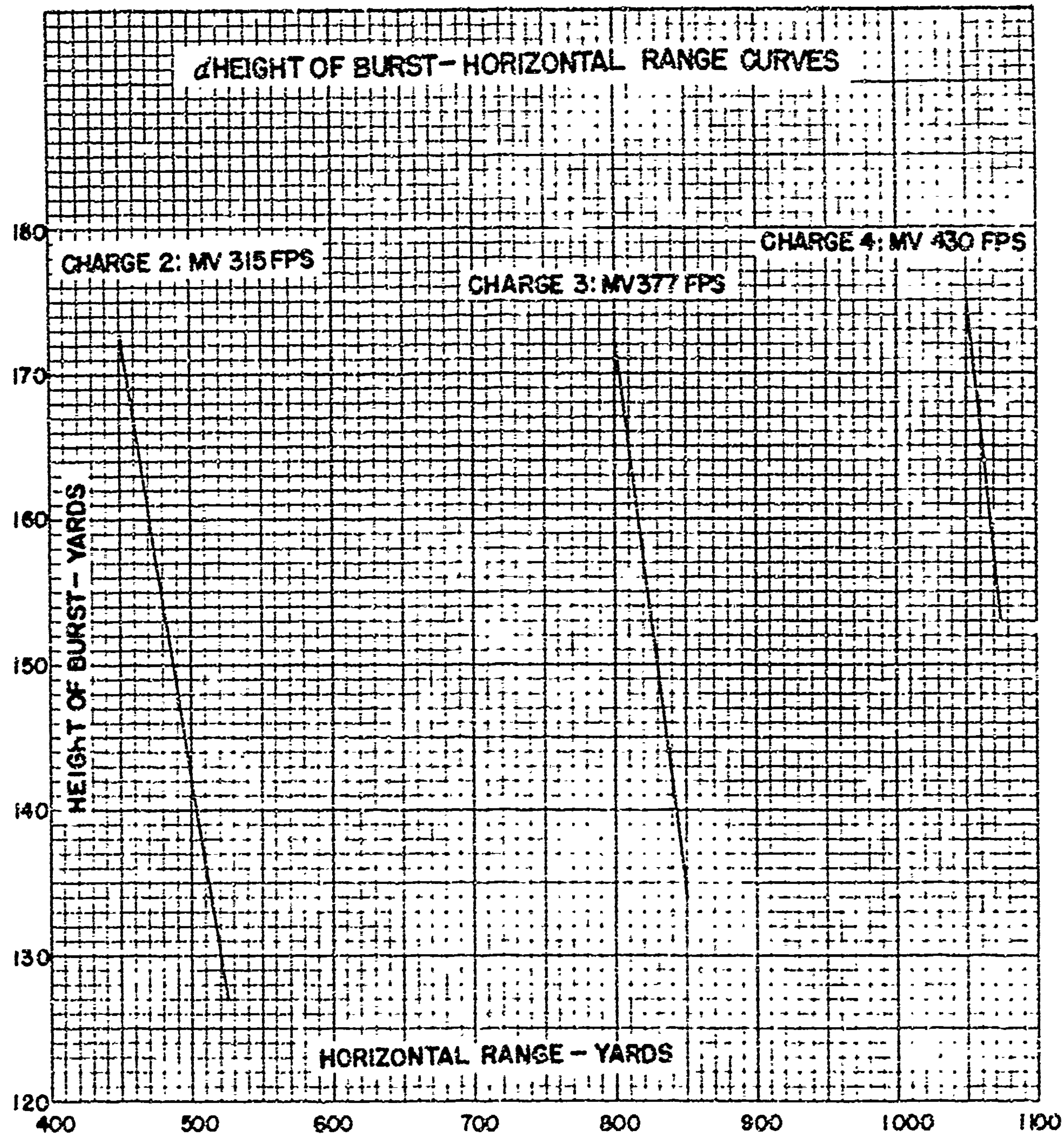


a.FORM FACTOR – ELEVATION CURVES(PROJ TYPE I)



b.BALLISTIC COEFFICIENT – ELEVATION CURVES (PROJ TYPE I)


c. ELEVATION—HORIZONTAL RANGE CURVES
CHARGE 2: MV 315 FPS
CHARGE 3: MV 377 FPS
CHARGE 4: MV 430 FPS
ELEVATION—DEG
70
65
60
55
50
45
HORIZONTAL RANGE — YARDS
400
500
600
700
800
900
1000
1100


dHEIGHT OF BURST – HORIZONTAL RANGE CURVES
CHARGE 2: MV 315 FPS
CHARGE 3: MV 377 FPS
CHARGE 4: MV 430 FPS
HEIGHT OF BURST – YARDS
HORIZONTAL RANGE – YARDS
120
130
140
150
160
170
180
400
500
600
700
800
900
1000
1100

SECTION IV

EFFECT DATA

Paragraph
Illumination - 7

7. **Illumination.** After burning about 15 seconds, the fuze releases the candle, which is carried by a parachute. In the functioning tests of the Illuminating Shell M83A1, the candles burned from 25 to 31 seconds.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 60-1-302

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
7 March 1949

# BALLISTIC AND ENGINEERING DATA
for
Shell, Smoke (WP), 60-mm, M302
with
Fuze, PD, M82

Section — Paragraph
I General ---------- 1
II Description -------- 2 - 4
III Exterior ballistic data -- 5 - 6
IV Effect data---------- 7

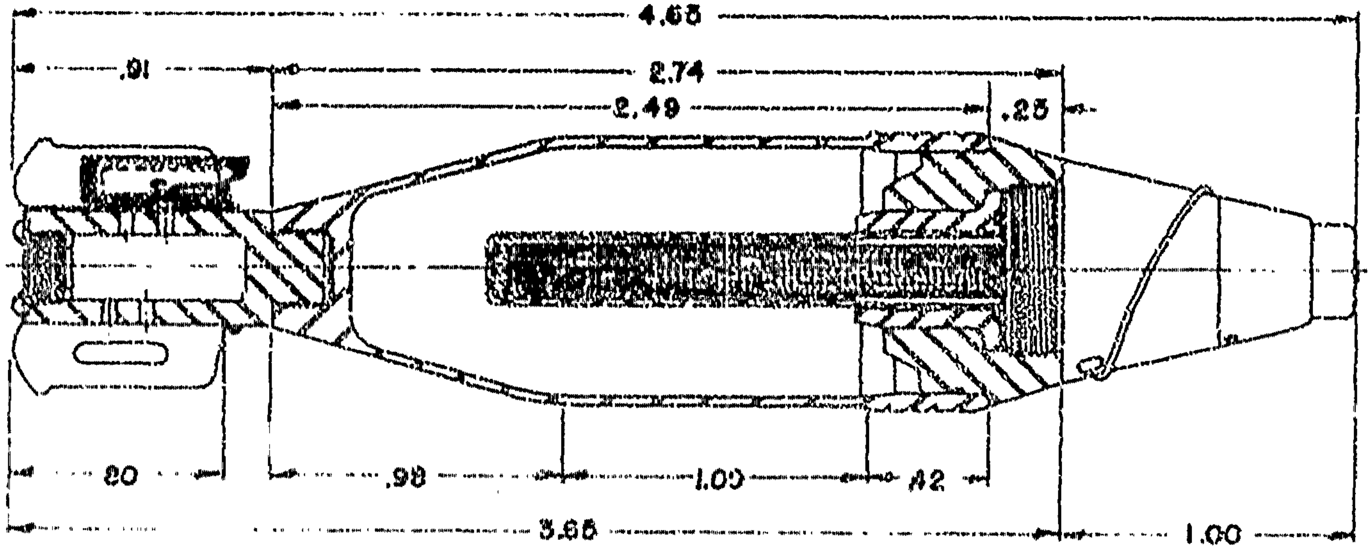
SECTION I

GENERAL

Paragraph
Purpose ------------------------------- 1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 60-mm Smoke (White Phosphorus) Shell M302 with the Point Detonating Fuze M82. This information is collected from the drawings, reports, and firing tables pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 2.362"



SHELL, SMOKE (WP), 60-MM, M302
FUZE, PD, M82

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell:	Metal parts assembly	75-2-360
Fins:	Assembly and details	75-2-285
Fuze:	Assembly	73-1-195
	Details	73-1-163,196 etc.
Complete round:	Assembly and marking diagram	75-1-218

3. Dimensions.

Fins:	Number	8
	Length	0.80 cal
	Length of assembly (outside)	0.91 cal
Shell:	Ogivo-conical boattail	0.98 cal
	Boattail to bourrelet	1.09 cal
	Bourrelet	0.42 cal
	Body	2.49 cal
	Adapter	0.25 cal
	Total length	2.74 cal
Fuze:	Length (outside)	1.00 cal
Length:	Shell and fin assembly	3.65 cal
	Shell, fin assembly, and fuze	4.65 cal

4. Physical characteristics.

Weight (standard)	3.98 lb
Weight without safety wire and propellant	3.95 lb

SECTION III

EXTERIOR BALLISTIC DATA

Paragraph
Aerodynamic data - 5
Firing table data - 6

5. Aerodynamic data. The following values of the drag coefficient were determined from the form factor given in paragraph 6a.

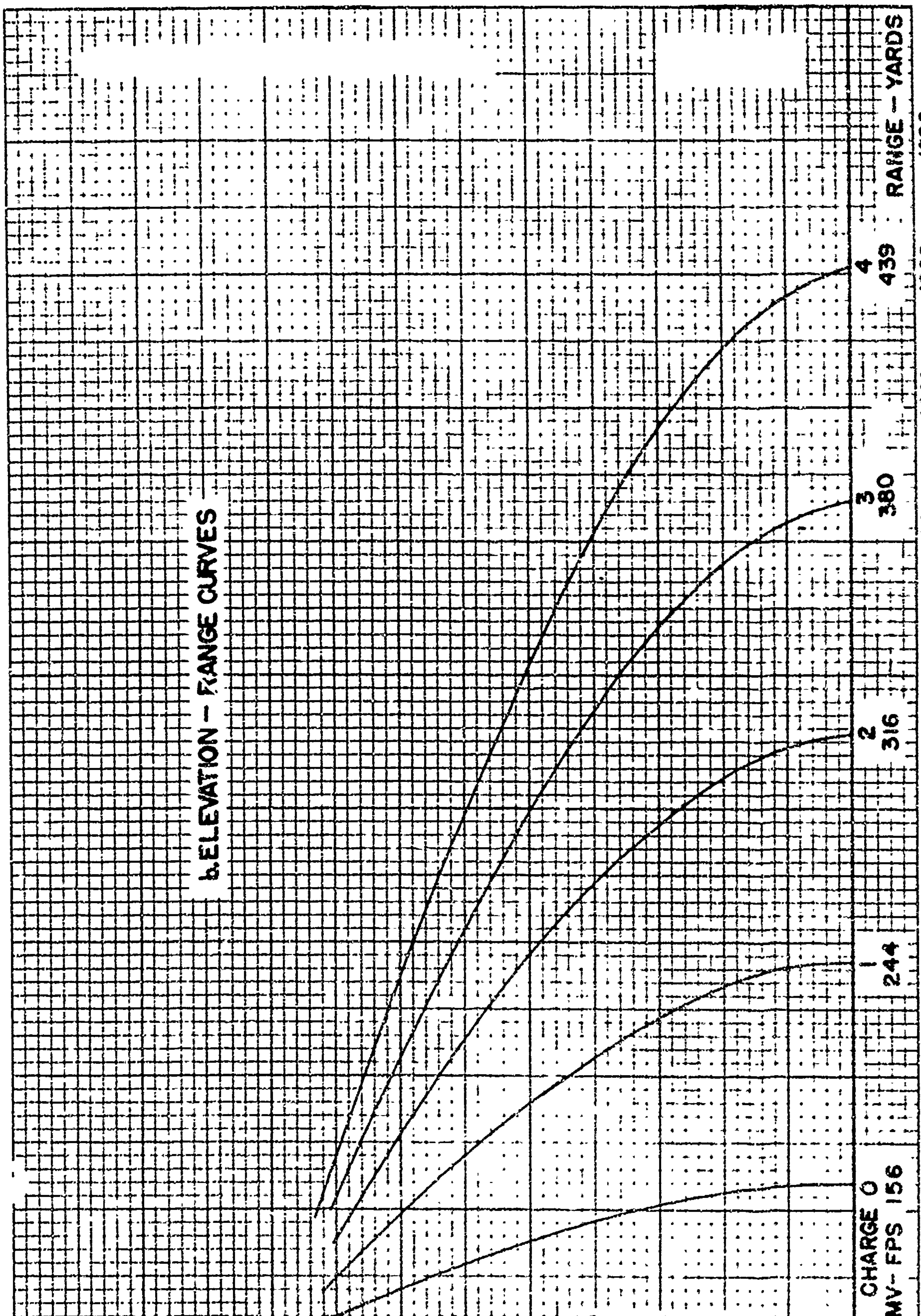
Muzzle Velocity fps	Drag Coefficient K_D
156	.086
244	.083
316	.079
380	.077
439	.075

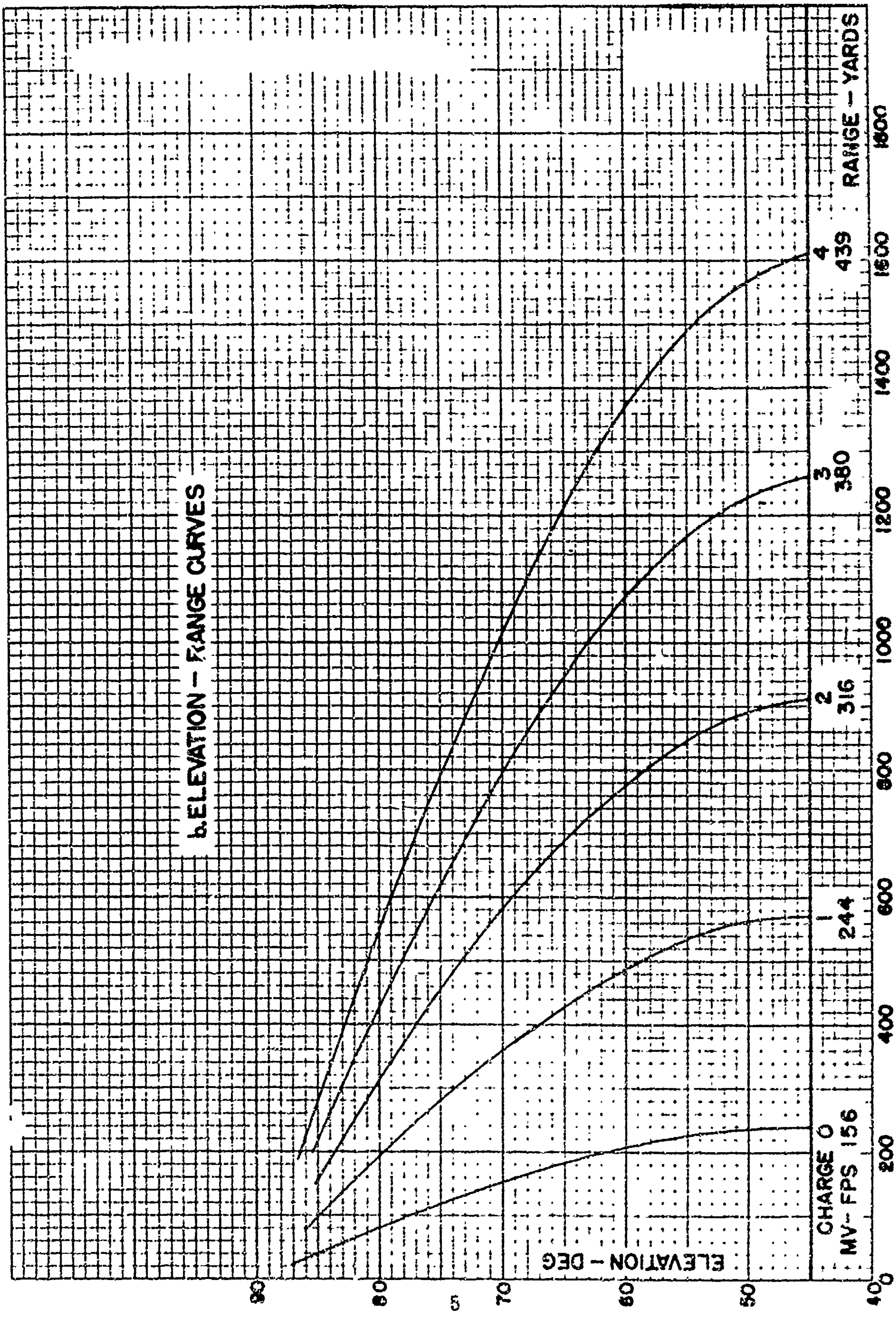
6. Firing table data. FT 60-F-1.

Mortar, 60-mm, M2 and M19. Smooth bore. Muzzle loading. Projectile weight: 3.98 lb. OCM items 26323 and 26708 recommended and approved standardization of the 60-mm WP Smoke Shell M302 with the PD Fuze M82.

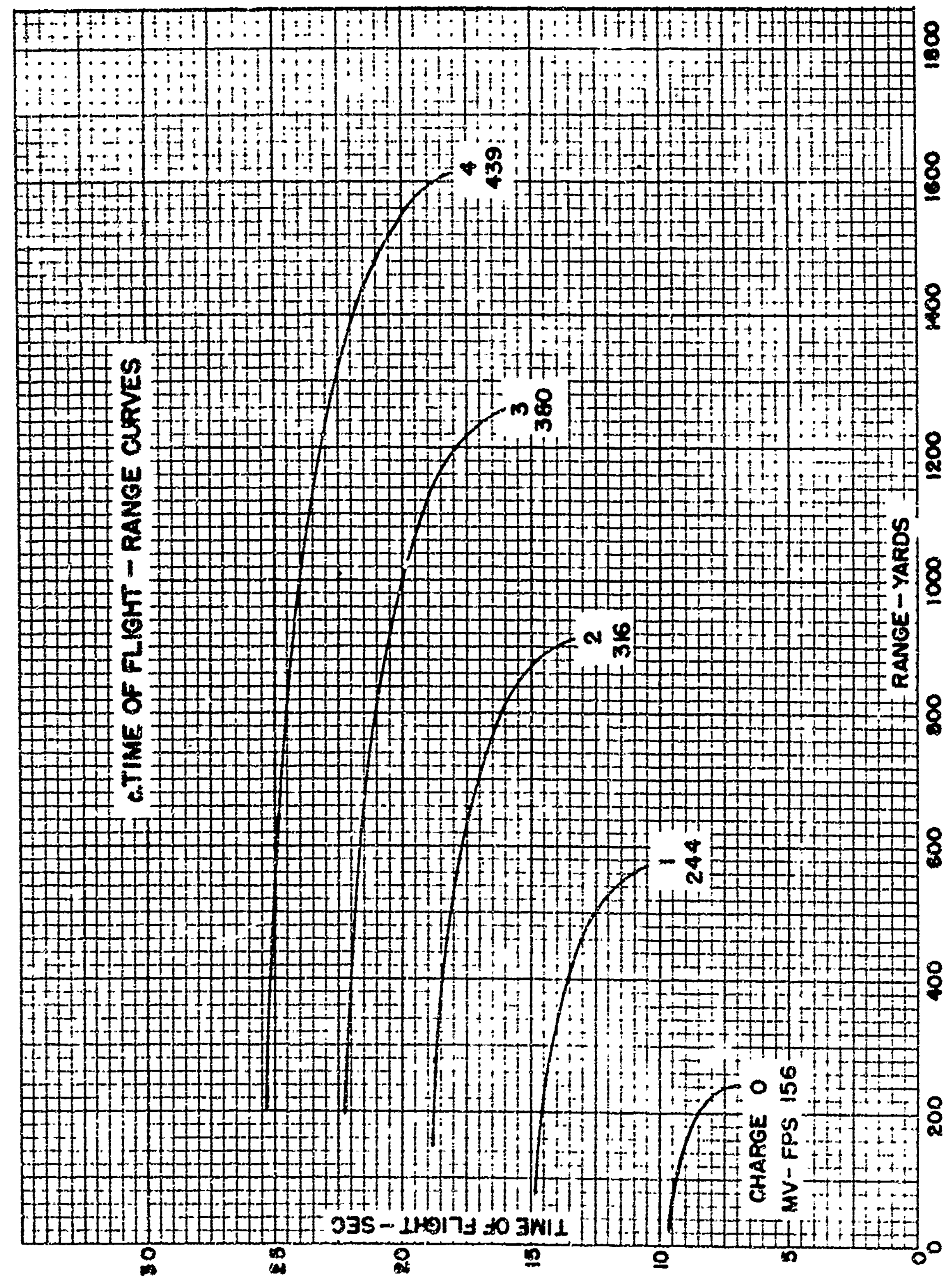
a. Form factor and ballistic coefficient. The following form factor and ballistic coefficient relative to Projectile Type 1 apply to all elevations and muzzle velocities.

i_1	0.905
C_1	0.788


b. ELEVATION – RANGE CURVES
RANGE – YARDS
0
200
400
600
800
1000
1200
1400
1600
1800
ELEVATION – DEG
40
50
60
70
80
90
CHARGE 0
MV- FPS 156
1
244
2
316
3
380
4
439


b. ELEVATION — RANGE CURVES

c. TIME OF FLIGHT – RANGE CURVES



SECTION IV

EFFECT DATA

Paragraph
White Phosphorus - 7

7. **White Phosphorus.** White Phosphorus (WP) is a pale yellow solid which burns to white smoke in air. The smoke persists for 10 minutes and has the same odor as burning matches. The burning pieces adhere to the skin and clothing; they should be washed with copper sulfate solution or immersed in water. WP is used to screen advancing troops, to start fires, and to harass enemy observers.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 75-1-41

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
7 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 75-mm, M41A1
with
Fuzes, PD, M48A2, and TSQ, M54

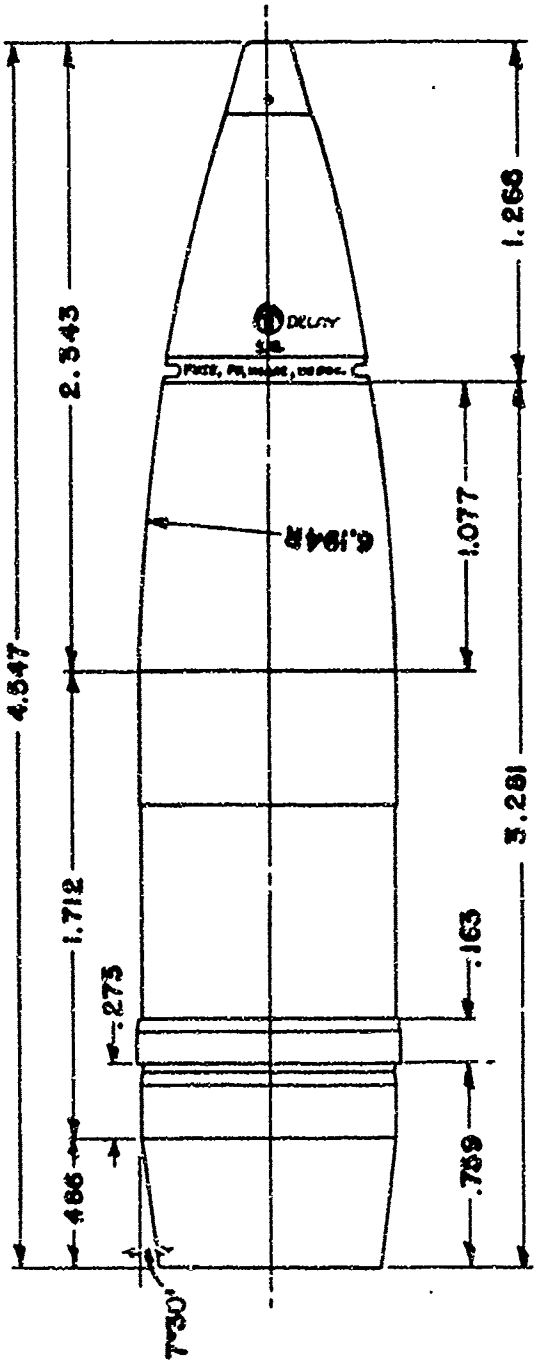
Section		Paragraphs
I	General - - - - - - - - - -	1
II	Description - - - - - - - -	2 - 4
III	Interior ballistic data - - -	5 - 6
VI	Exterior ballistic data - - -	7 - 8

SECTION I

GENERAL

	Paragraph
Purpose -	1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics and ballistics of the 75-mm High Explosive Shell M41A1 with the Point Detonating Fuze M48A2 and the Time and Super-quick Fuze M54. This information is collected from the drawings, reports and firing tables pertaining to this ammunition.



ALL DIMENSIONS IN CALIBERS
1 CAL = 2.953"

SHELL, HE, 75MM, M41A1
FUZE, PD, M48A2

SECTION II

DESCRIPTION

	Paragraph
Drawings -	2
Dimensions -	3
Physical characteristics -	4

2. Drawings.

Shell: Metal parts assembly, marking diagram and details	75-2-258
Booster M20: Assembly	73-2-112
Fuze, PD, M48A2: Assembly	73-2-140
Details	73-2-143, etc.
Fuze, TSQ, M54: Assembly	73-3-154
Details	73-3-156, 157, 158, 159, 160

3. Dimensions.

Boattail: Angle	7°30'
Length	0.486 cal
Band: Distance from boattail	0.273 cal
Distance from base	0.759 cal
Width	0.163 cal
Cylindrical body: Length	1.712 cal
Ogive: Length	1.077 cal
Radius of arc	6.194 cal
Fuze: Outside length	1.266 cal
Length: Shell	3.281 cal
Shell and Fuze	4.547 cal
Ogive and Fuze	2.343 cal

4. Physical characteristics.

Mean weight: Zone 1	13.6 lb
Zone 2 (standard)	13.9 lb
Zone 3	14.2 lb
Axial moment of inertia (estimated)	0.118 lb. ft^2
Transverse moment of inertia (est.)	1.09 lb. ft^2

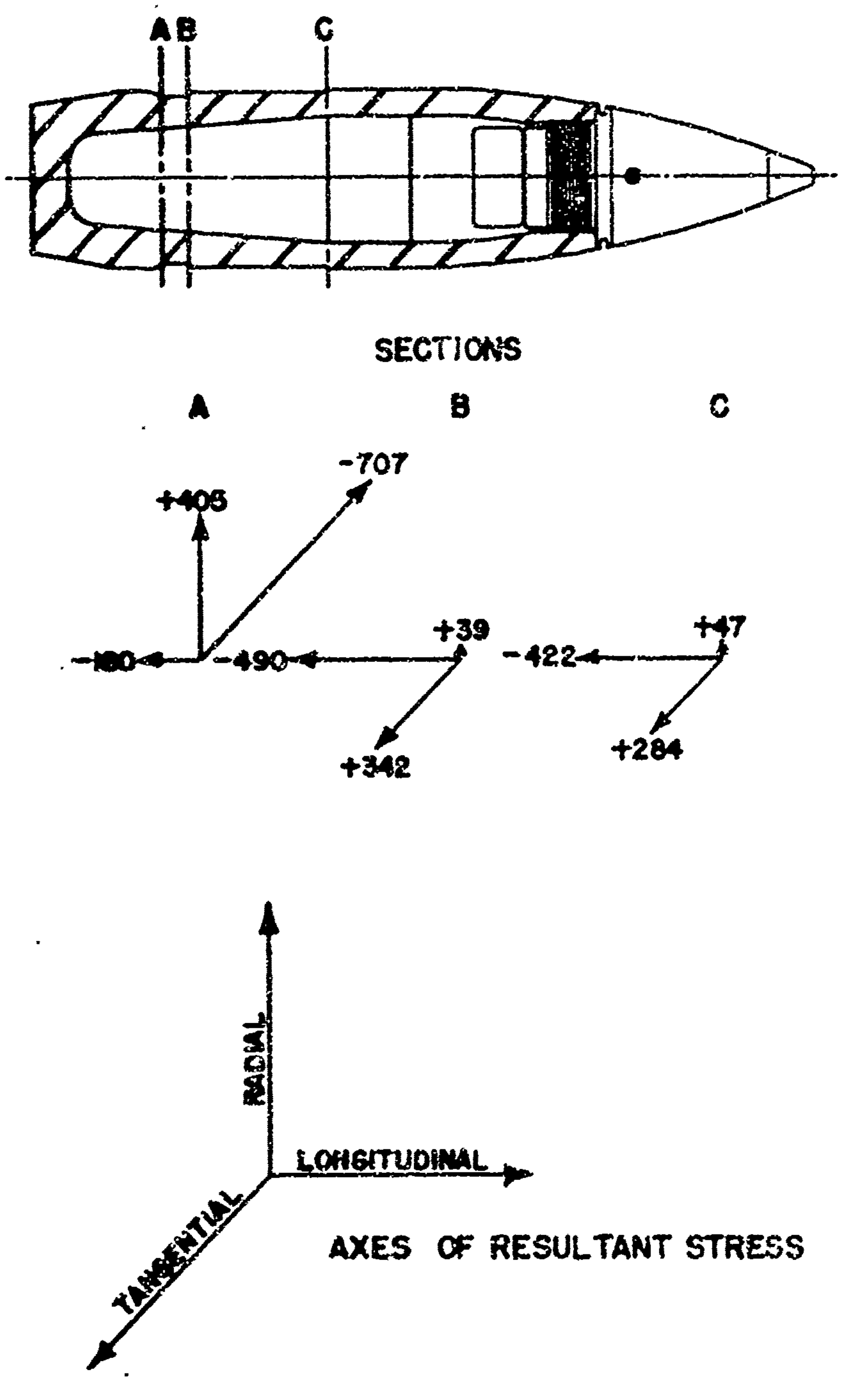


DIAGRAM OF RESULTANT STRESSES

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses- -	5
Theoretical yaw in bore -	6

5. **Stresses.** The following table and the graphical representation on page 4 show the longitudinal, radial and tangential stress at each of three sections: (A) the rear corner of the band seat, (B) the front of the band seat, and (C) immediately behind the bourrelet.

Howitzer	75-mm M1, M1A1, M2 and M3
Twist of rifling	1/20
Cross-sectional area of bore	7.0043 sq in.
Rated maximum pressure	29,000 psi
Total weight of projectile	13.90 lb
Muzzle velocity	1,270 fps
Density of filler (TNT)	0.057 lb per cu in.

Resultant Stress* 100 psi	Section A	Section B	Section C
Longitudinal	- 180	- 490	- 422
Radial	+ 405	+ 39	+ 47
Tangential	- 707	+ 342	+ 284

* + denotes tension, - denotes compression.

6. **Theoretical yaw in bore.**

Minimum	13.6 min
Maximum	18.7 min

SECTION IV

EXTERIOR BALLISTIC DATA

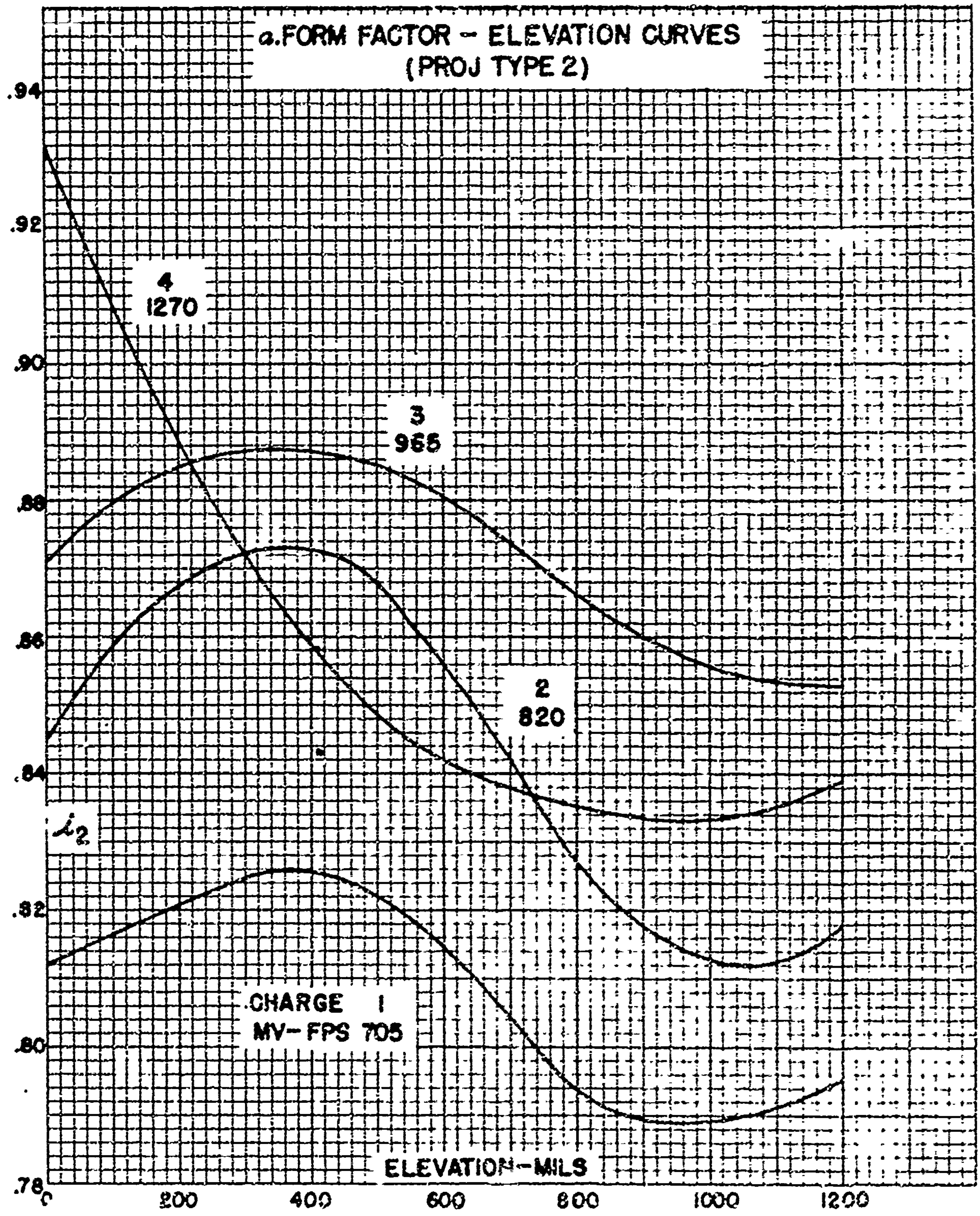
Paragraph
Aerodynamic data - 7
Firing table data - 8

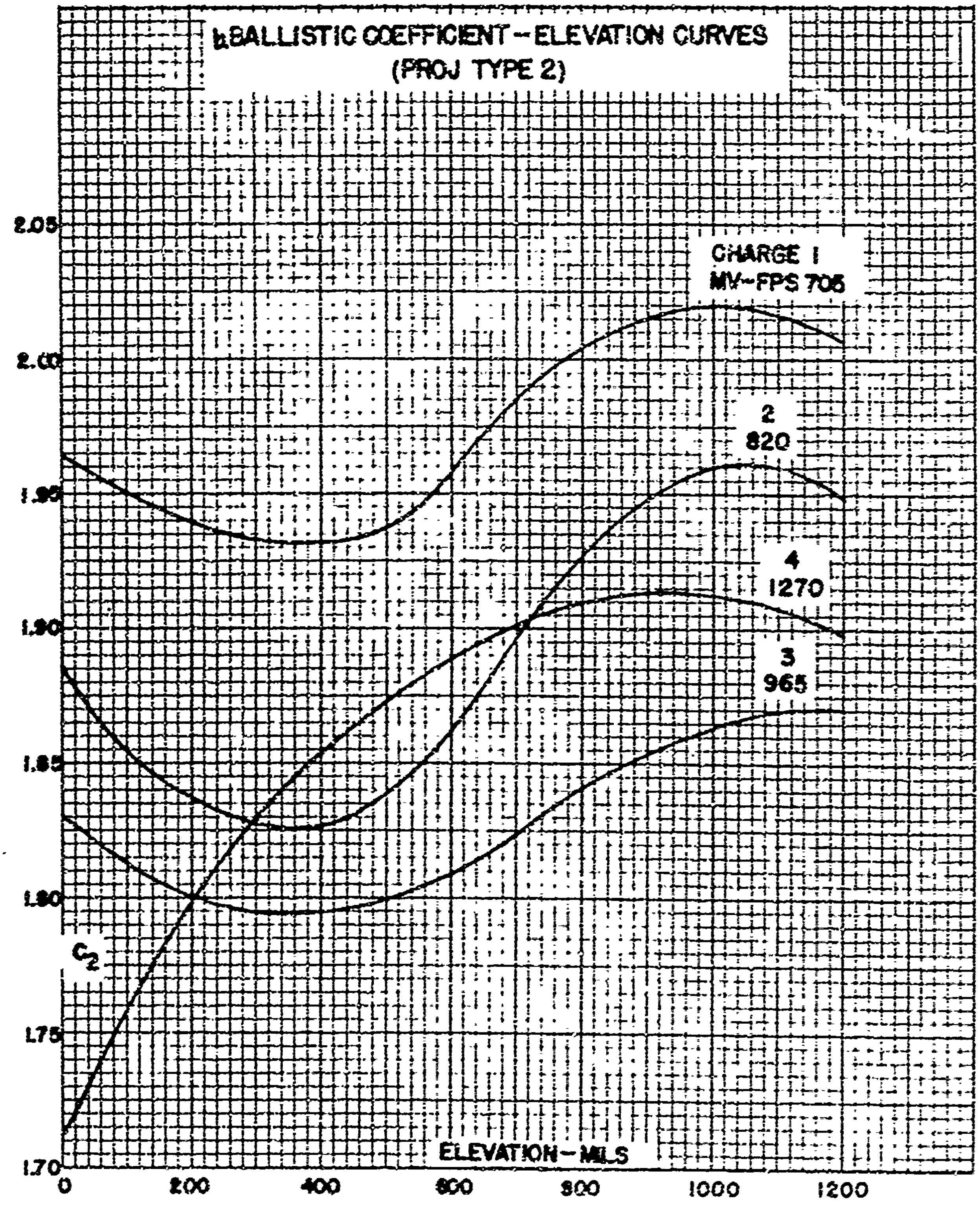
7. **Aerodynamic data.** The trajectories for the 75-mm Howitzers were based on the G_2 drag function, with ballistic coefficients determined from range firings (see par. 8b). The extrapolated values of the ballistic coefficient at zero elevation and the corresponding form factors and drag coefficients are tabulated below.

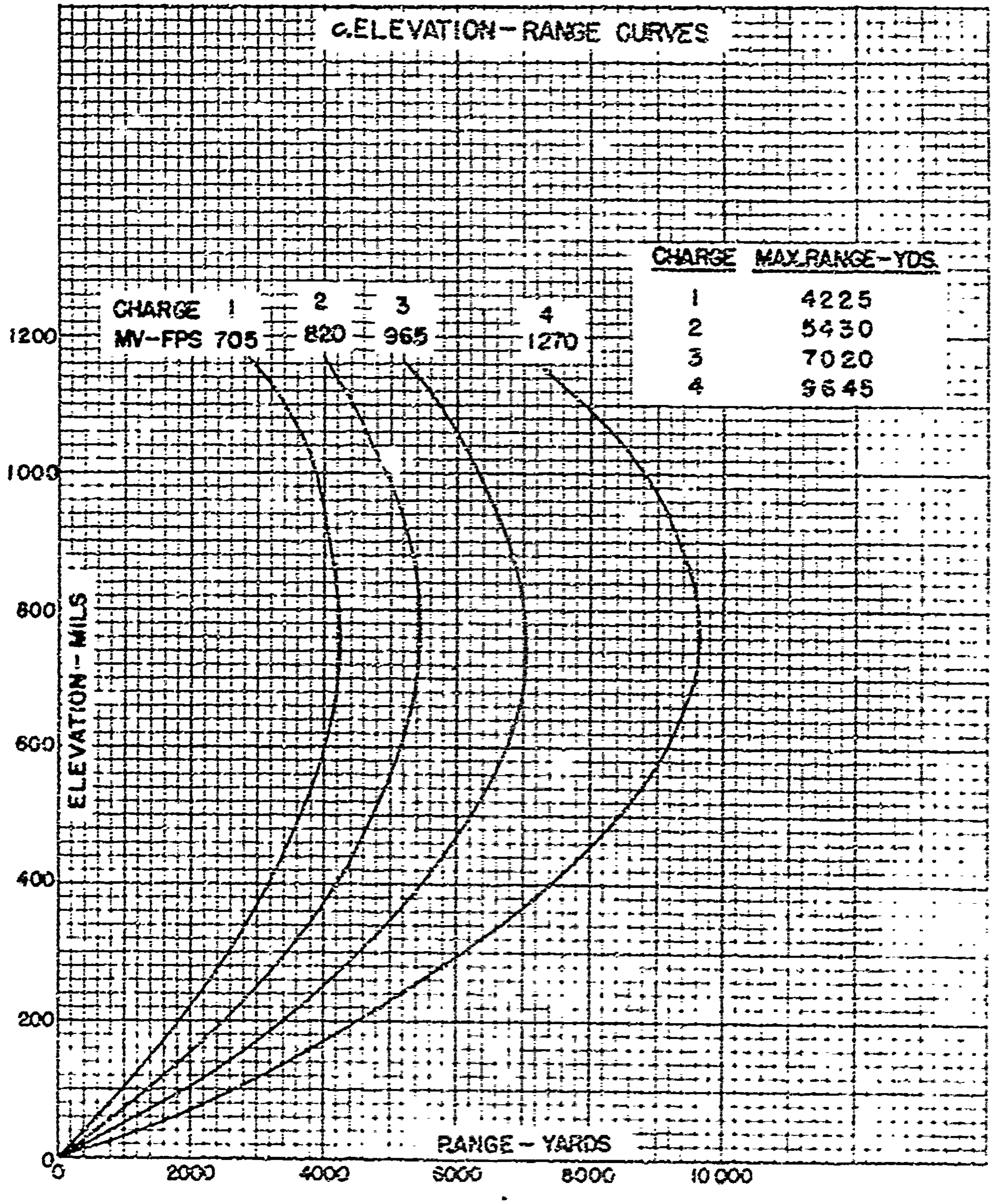
Muzzle Velocity fps	Ballistic Coefficient C_2	Form Factor i_2	Drag Coefficient K_D
705	1.964	.81	.057
820	1.886	.85	.056
965	1.830	.87	.059
1270	1.714	.93	.149

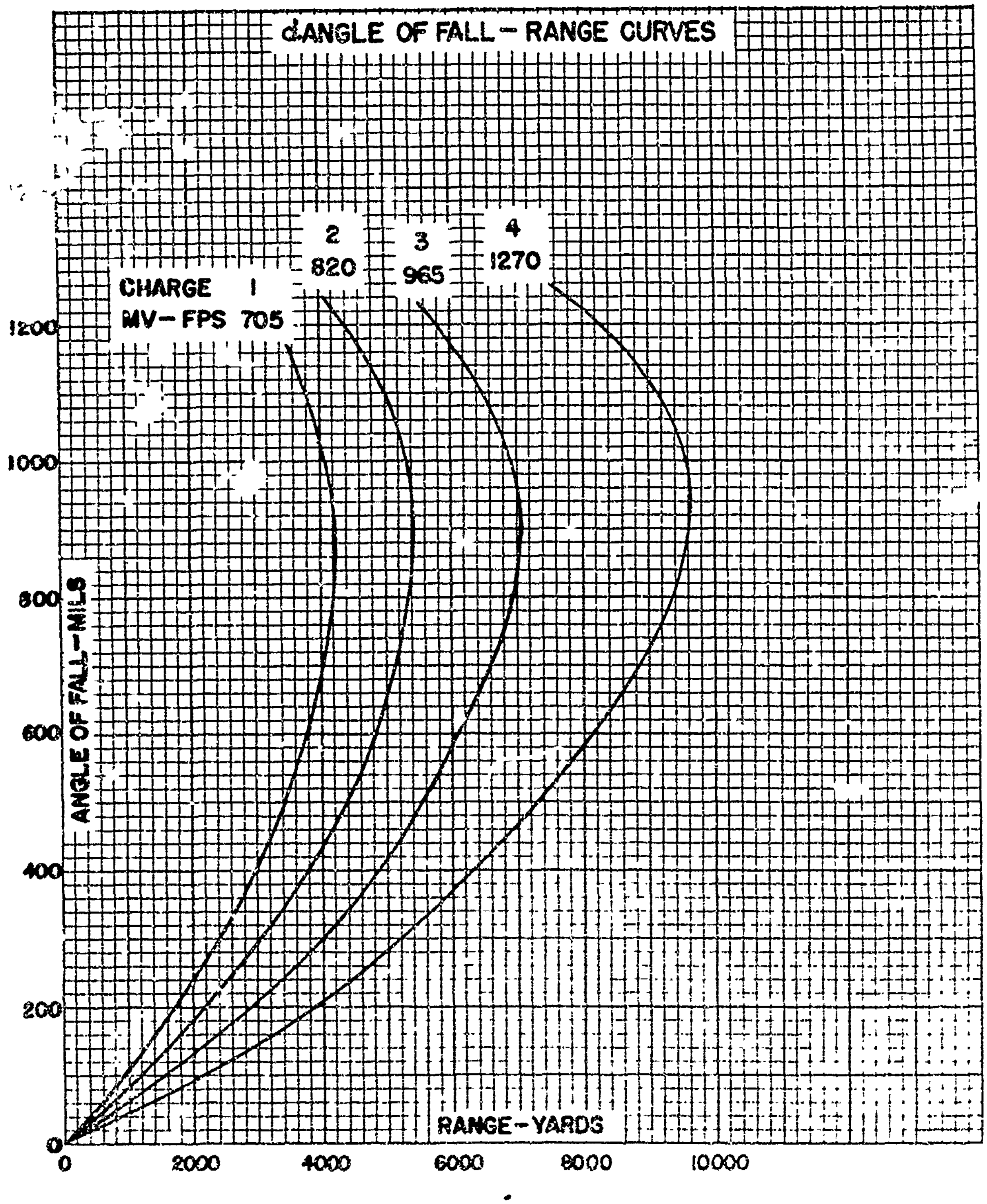
8. **Firing table data.** FT 75-I-4.

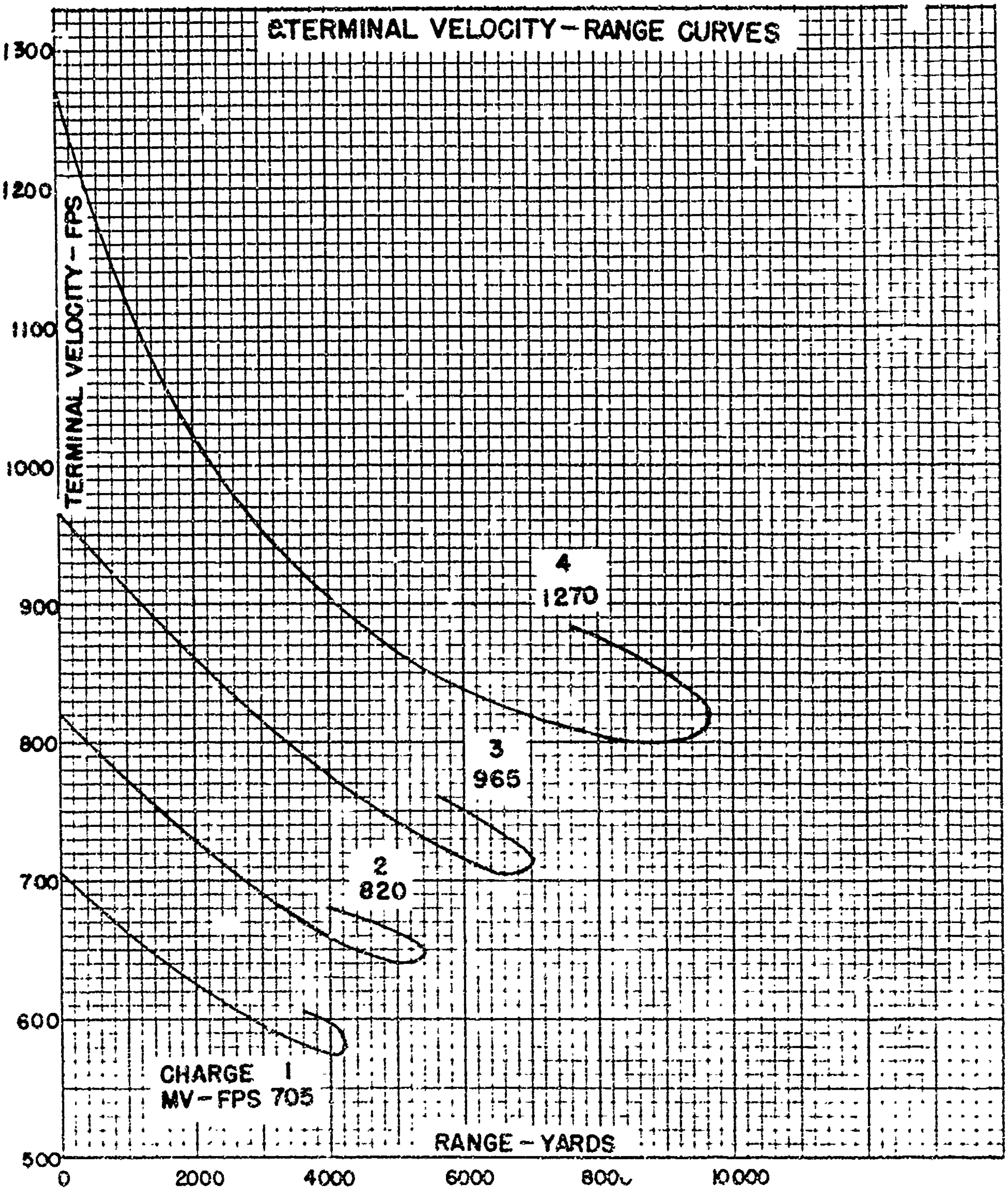
Howitzer, 75-mm, M1A1, M2 and M3. Twist of rifling: 1/20. OCM items 15194 and 15278 recommended and approved reclassifying the HE Shell M41A1 as substitute standard for the Howitzers.

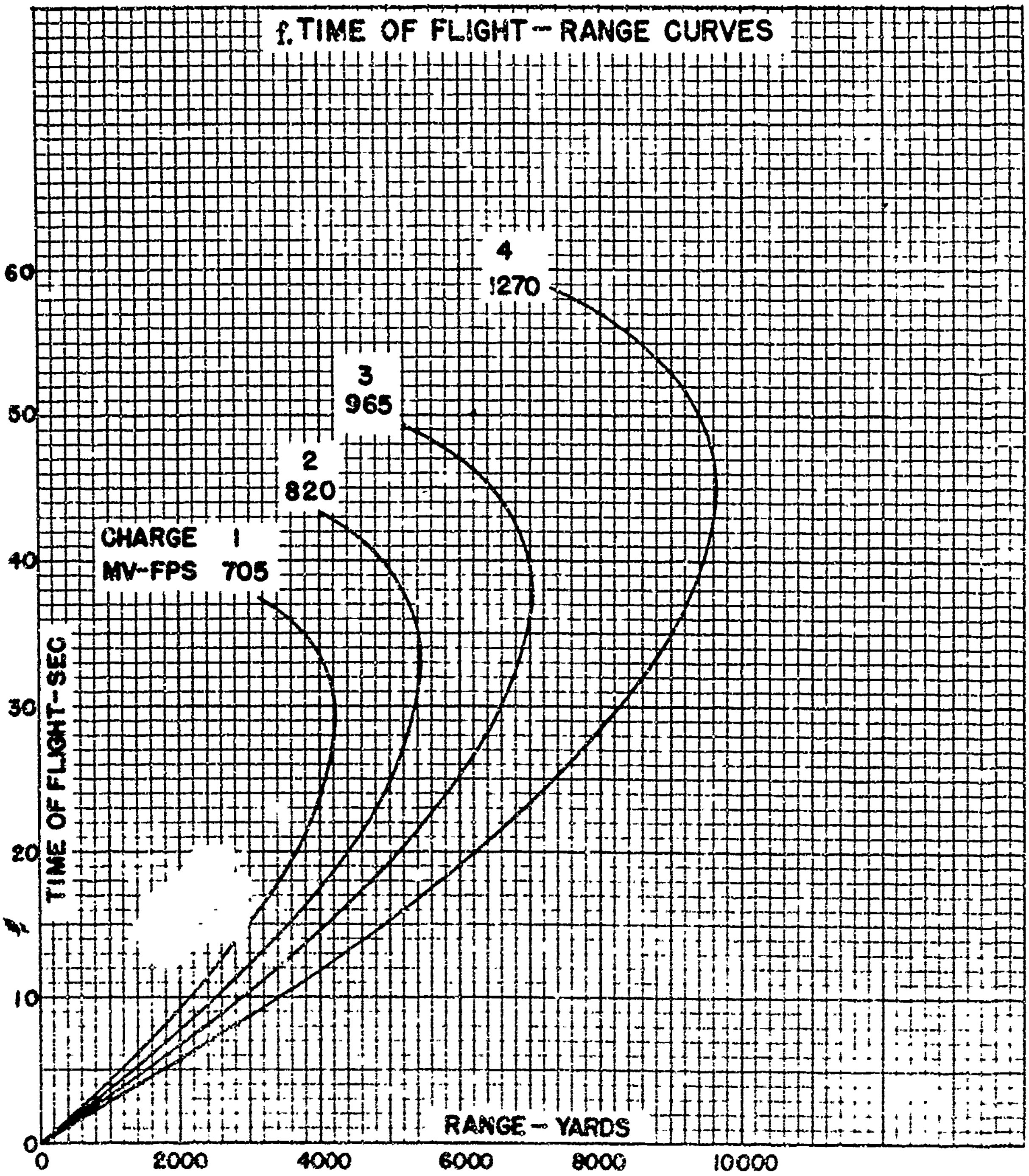

a. FORM FACTOR – ELEVATION CURVES
(PROJ TYPE 2)
4
1270
3
965
2
820
CHARGE 1
MV–FPS 705
i_2
.94
.92
.90
.88
.86
.84
.82
.80
.78
0
200
400
600
800
1000
1200
ELEVATION–MILS

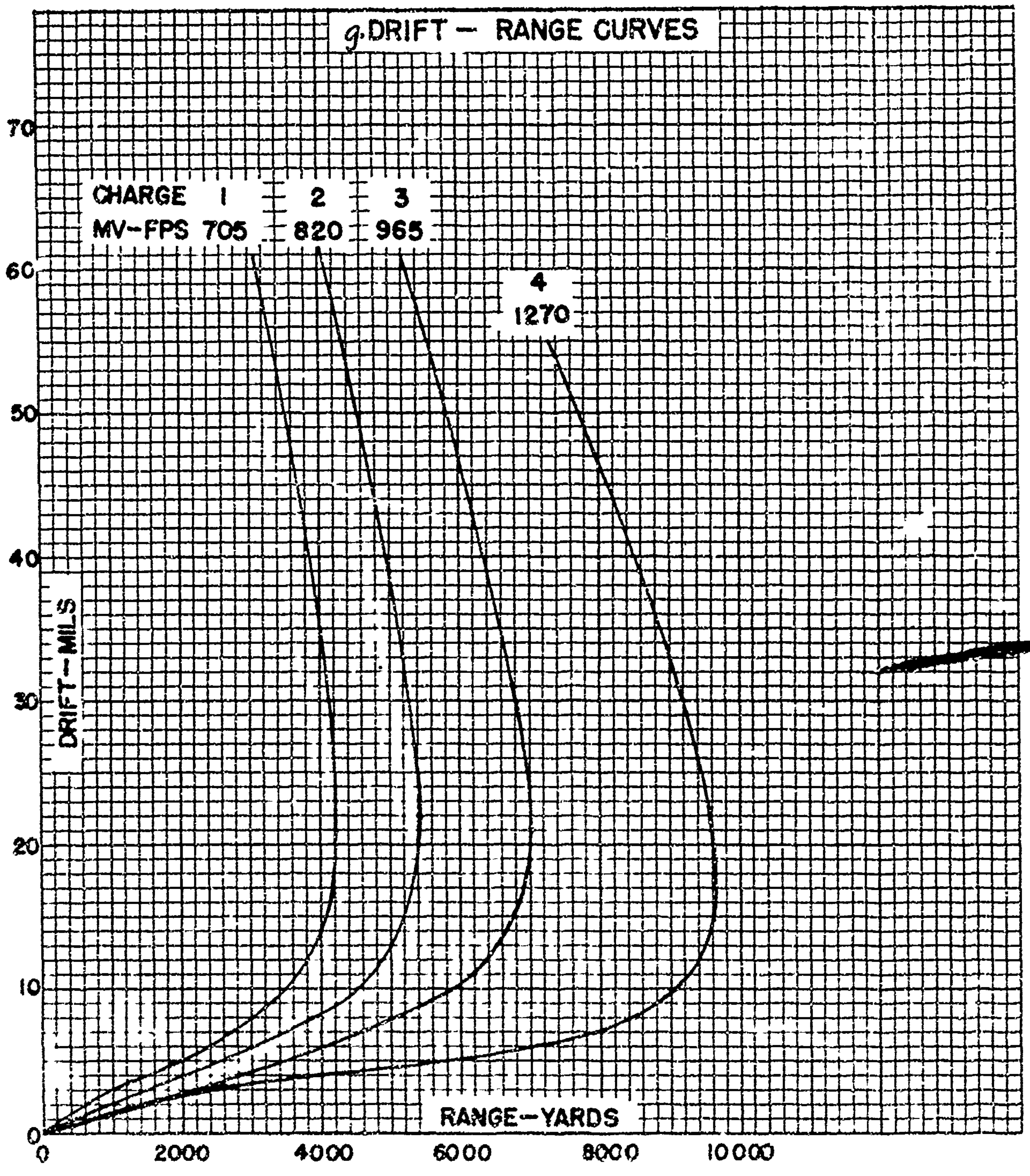

b. BALLISTIC COEFFICIENT – ELEVATION CURVES
(PROJ TYPE 2)
CHARGE 1
MV–FPS 705
2
820
4
1270
3
965
C_2
2.05
2.00
1.95
1.90
1.85
1.80
1.75
1.70
0
200
400
600
800
1000
1200
ELEVATION – MILS

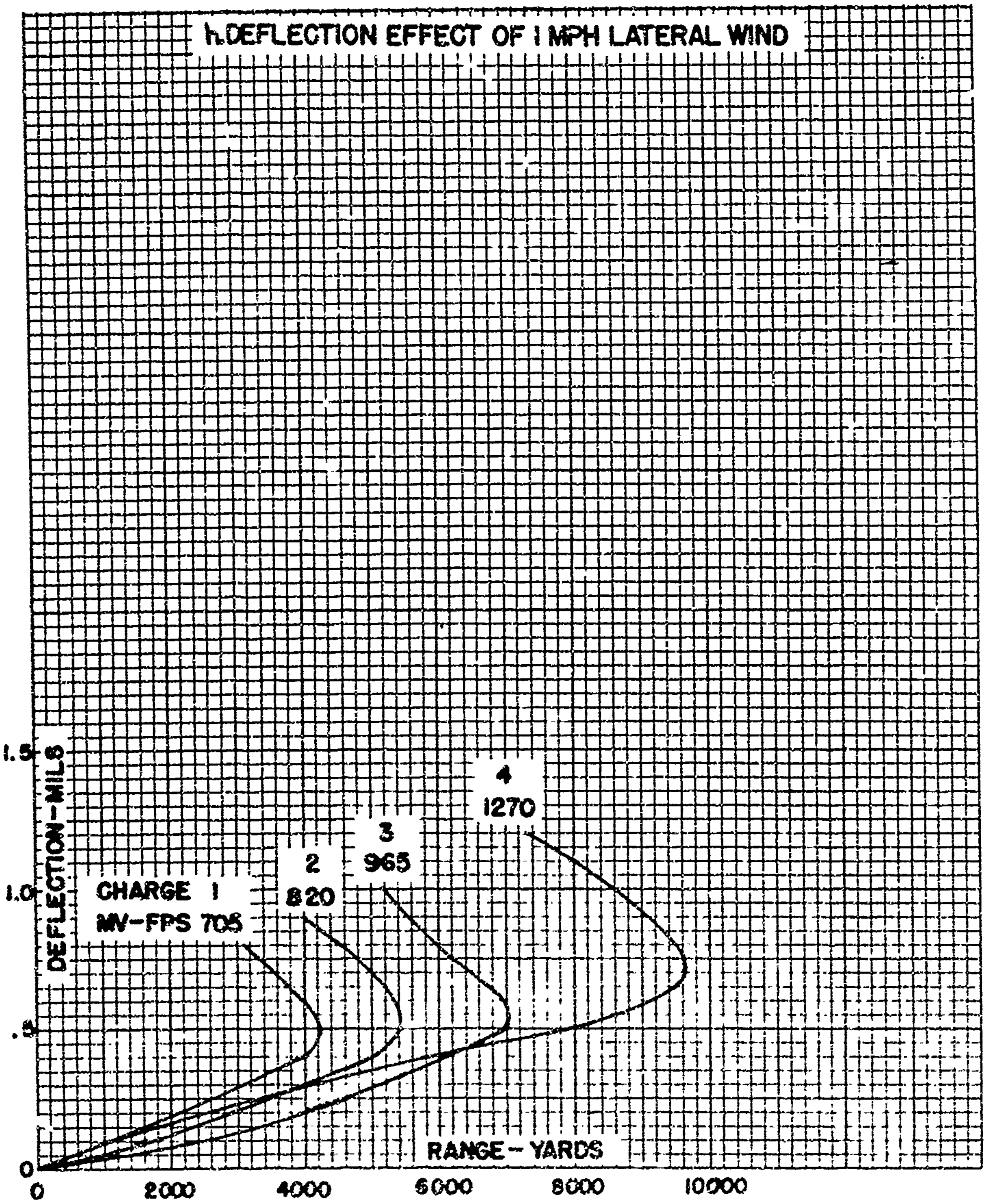

c. ELEVATION – RANGE CURVES
CHARGE 1 2 3 4
MV-FPS 705 820 965 1270
CHARGE MAX.RANGE–YDS.
1 4225
2 5430
3 7020
4 9645
ELEVATION – MILS
0
200
400
600
800
1000
1200
RANGE – YARDS
0
2000
4000
6000
8000
10 000

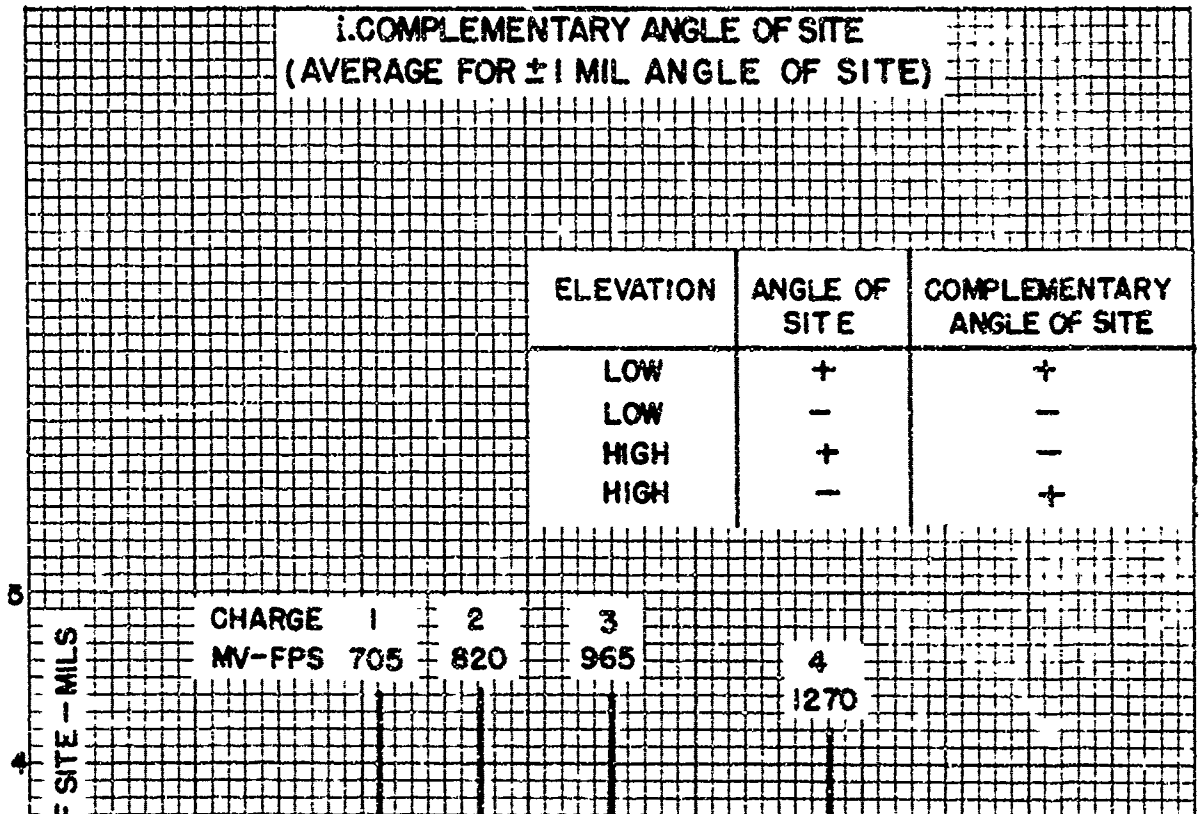

dANGLE OF FALL – RANGE CURVES
CHARGE 1
MV – FPS 705
2
820
3
965
4
1270
ANGLE OF FALL – MILS
RANGE – YARDS
0
200
400
600
800
1000
1200
0
2000
4000
6000
8000
10000


TERMINAL VELOCITY - RANGE CURVES
TERMINAL VELOCITY - FPS
1300
1200
1100
1000
900
800
700
600
500
4
1270
3
965
2
820
CHARGE 1
MV-FPS 705
RANGE - YARDS
0
2000
4000
6000
8000
10000


f. TIME OF FLIGHT — RANGE CURVES
CHARGE 1
MV-FPS 705
2
820
3
965
4
1270
TIME OF FLIGHT-SEC
0
10
20
30
40
50
60
RANGE — YARDS
0
2000
4000
6000
8000
10000

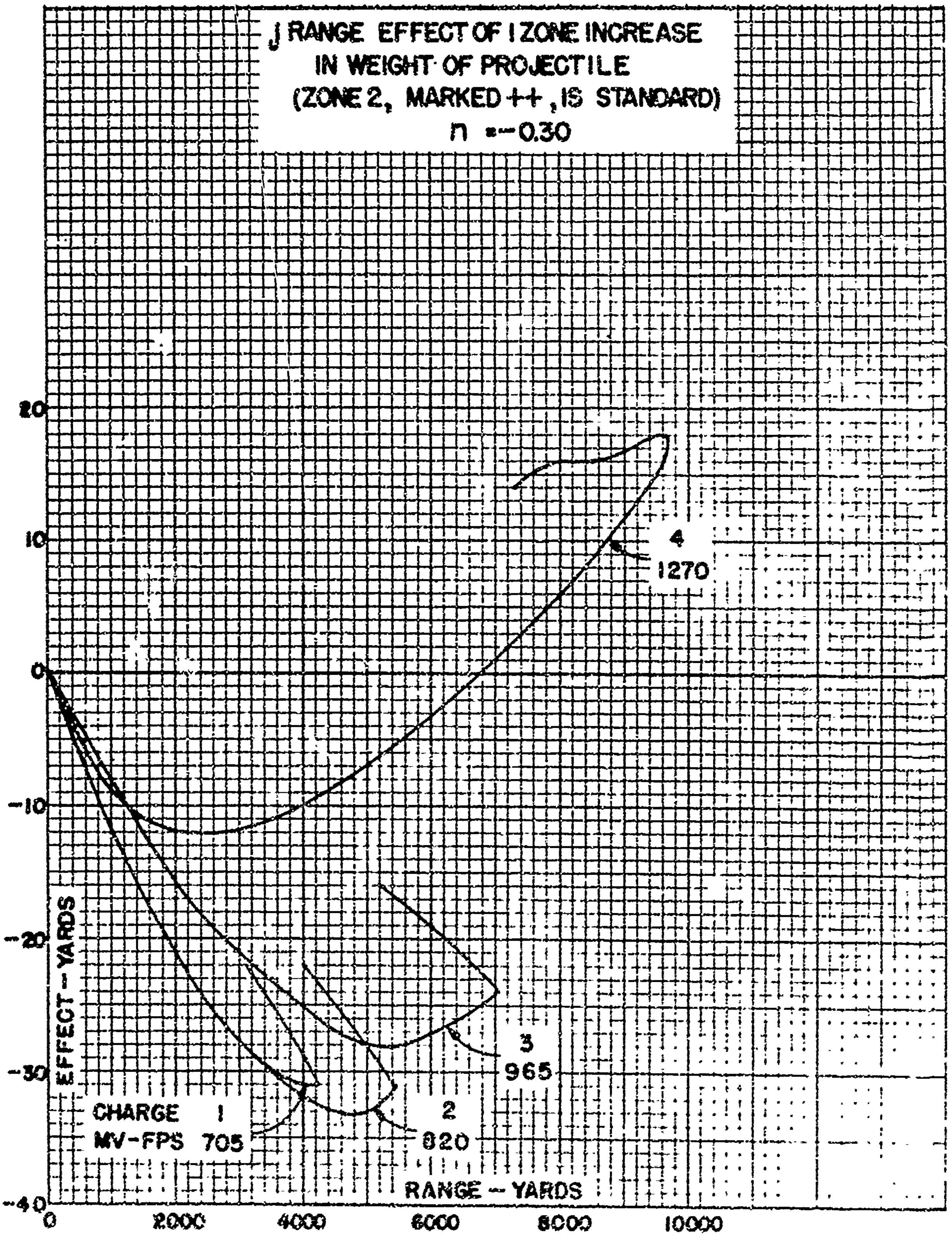

g. DRIFT — RANGE CURVES
CHARGE 1 2 3
MV-FPS 705 820 965
4
1270
DRIFT—MILS
0
10
20
30
40
50
60
70
RANGE—YARDS
0
2000
4000
6000
8000
10000


h.DEFLECTION EFFECT OF I MPH LATERAL WIND
DEFLECTION-MILS
1.5
1.0
.5
0
RANGE-YARDS
0
2000
4000
6000
8000
10000
CHARGE I
MV-FPS 705
2
820
3
965
4
1270

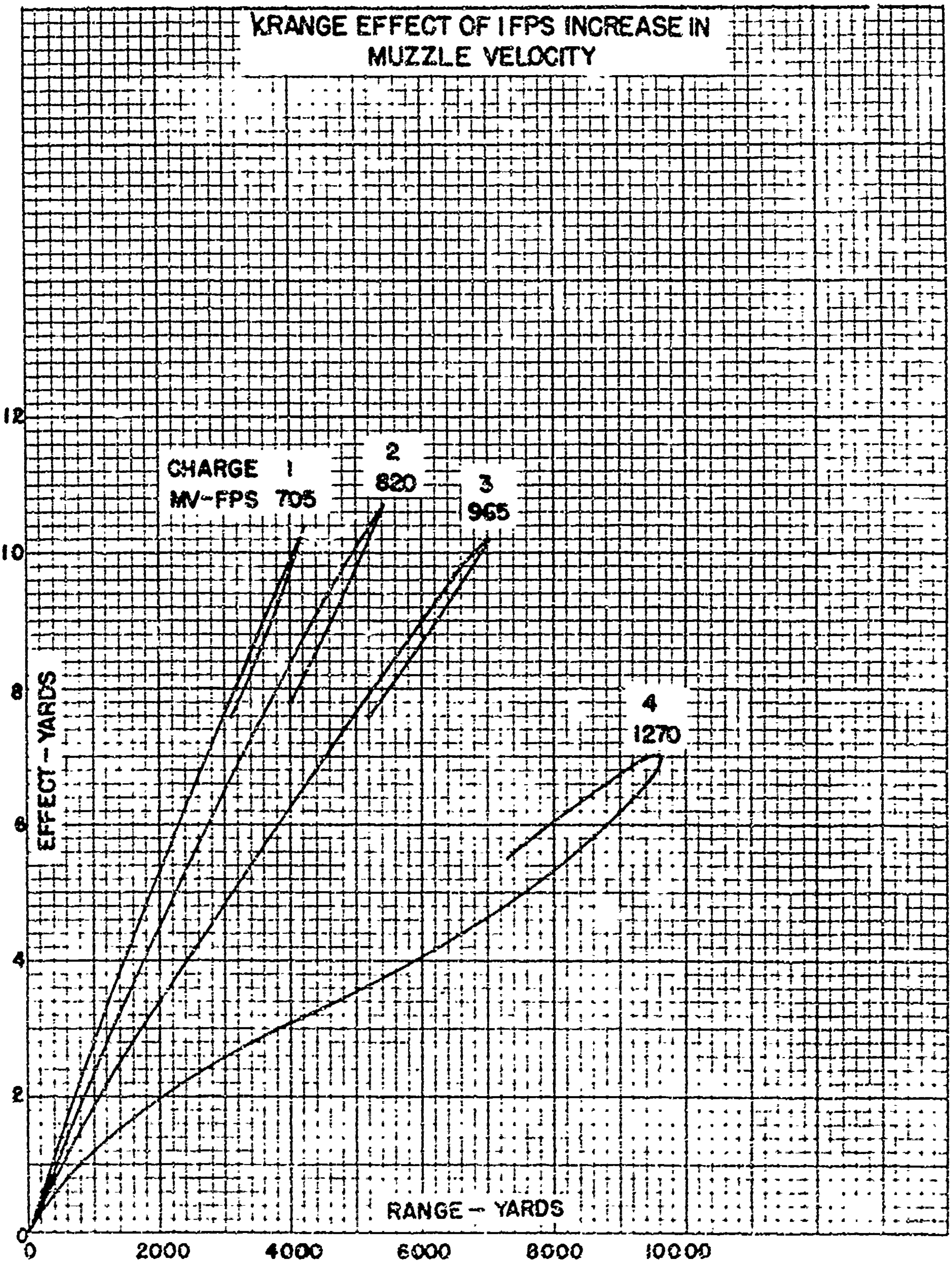


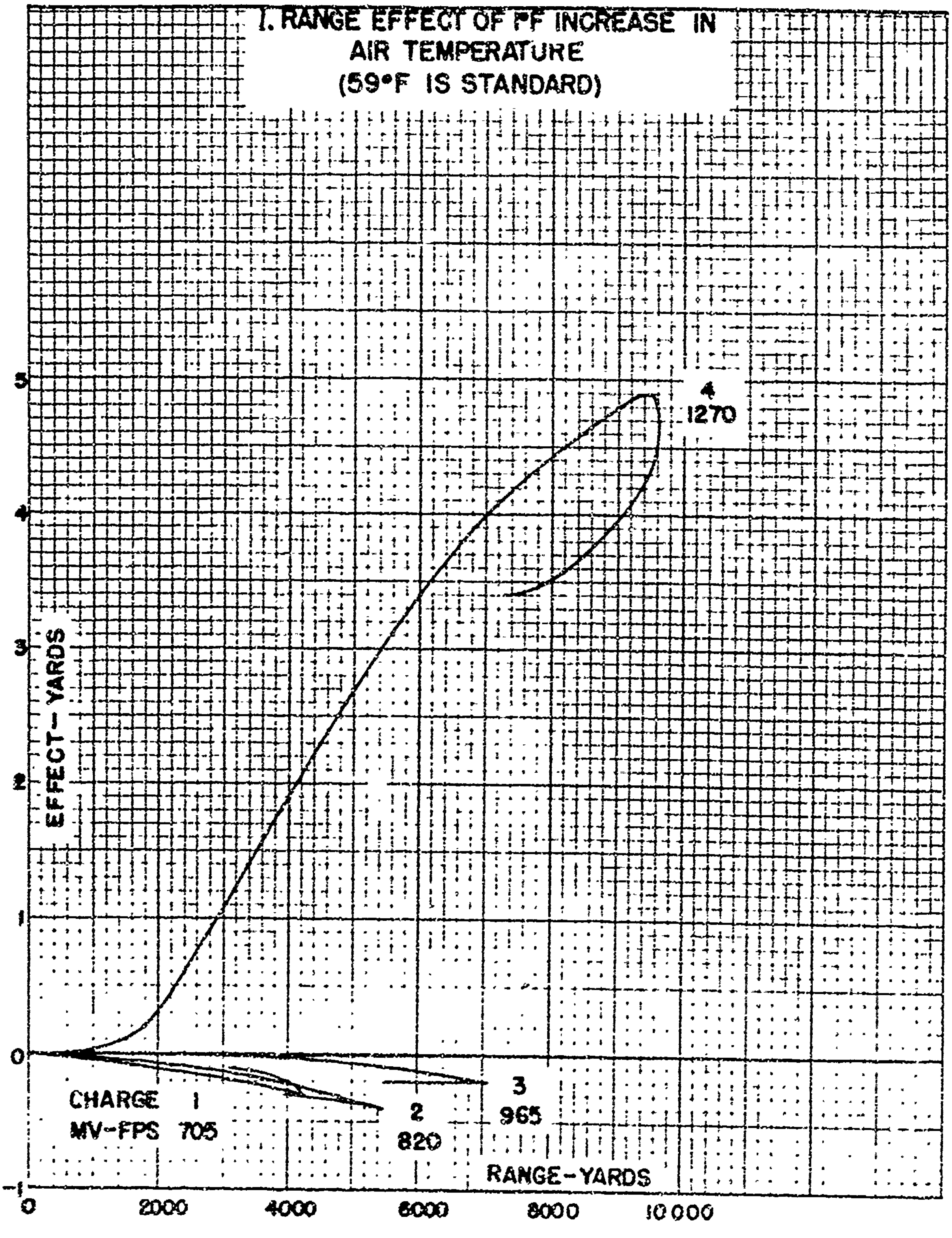
i. COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± 1 MIL ANGLE OF SITE)

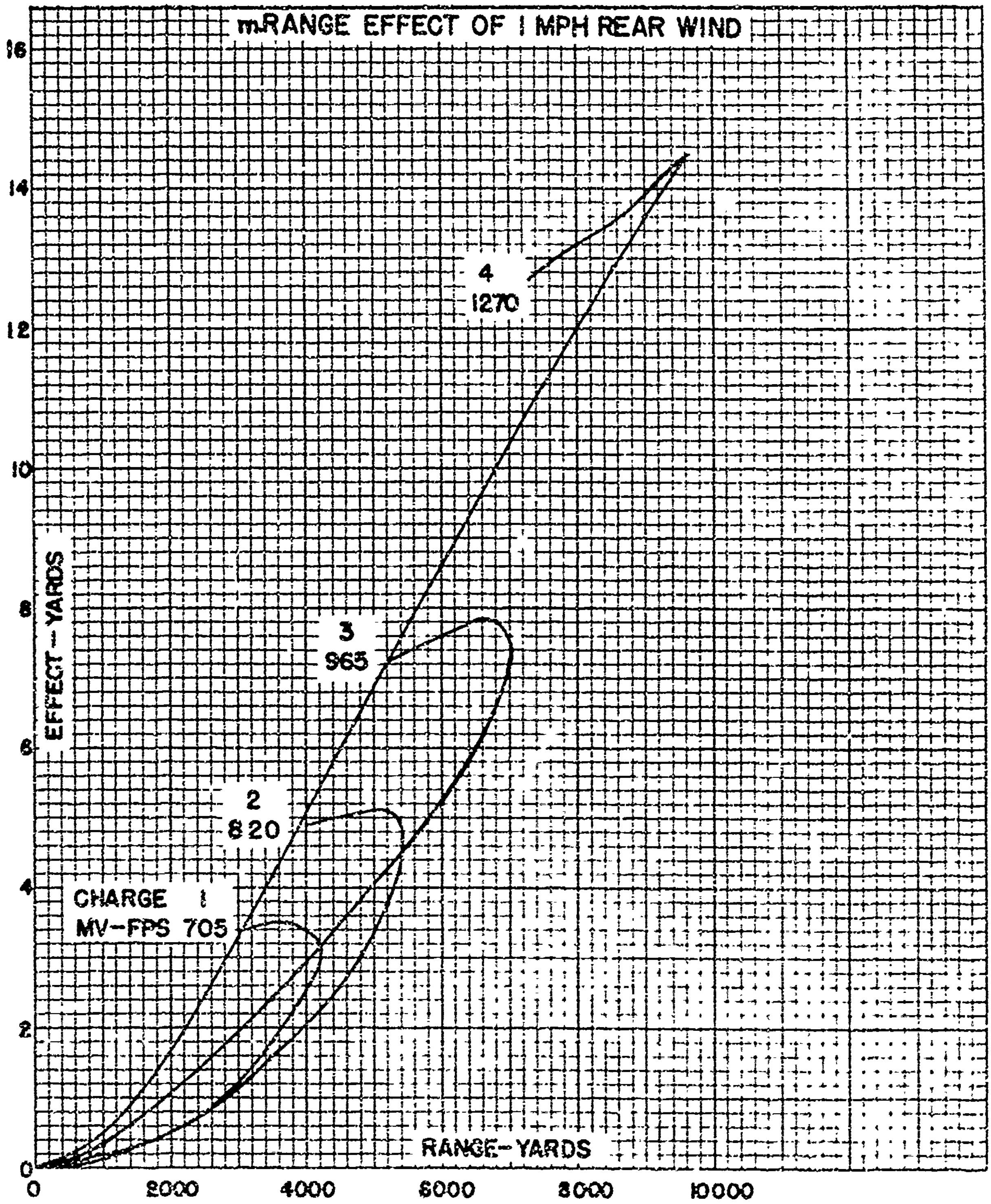
ELEVATION	ANGLE OF SITE	COMPLEMENTARY ANGLE OF SITE
LOW	+	+
LOW	−	−
HIGH	+	−
HIGH	−	+

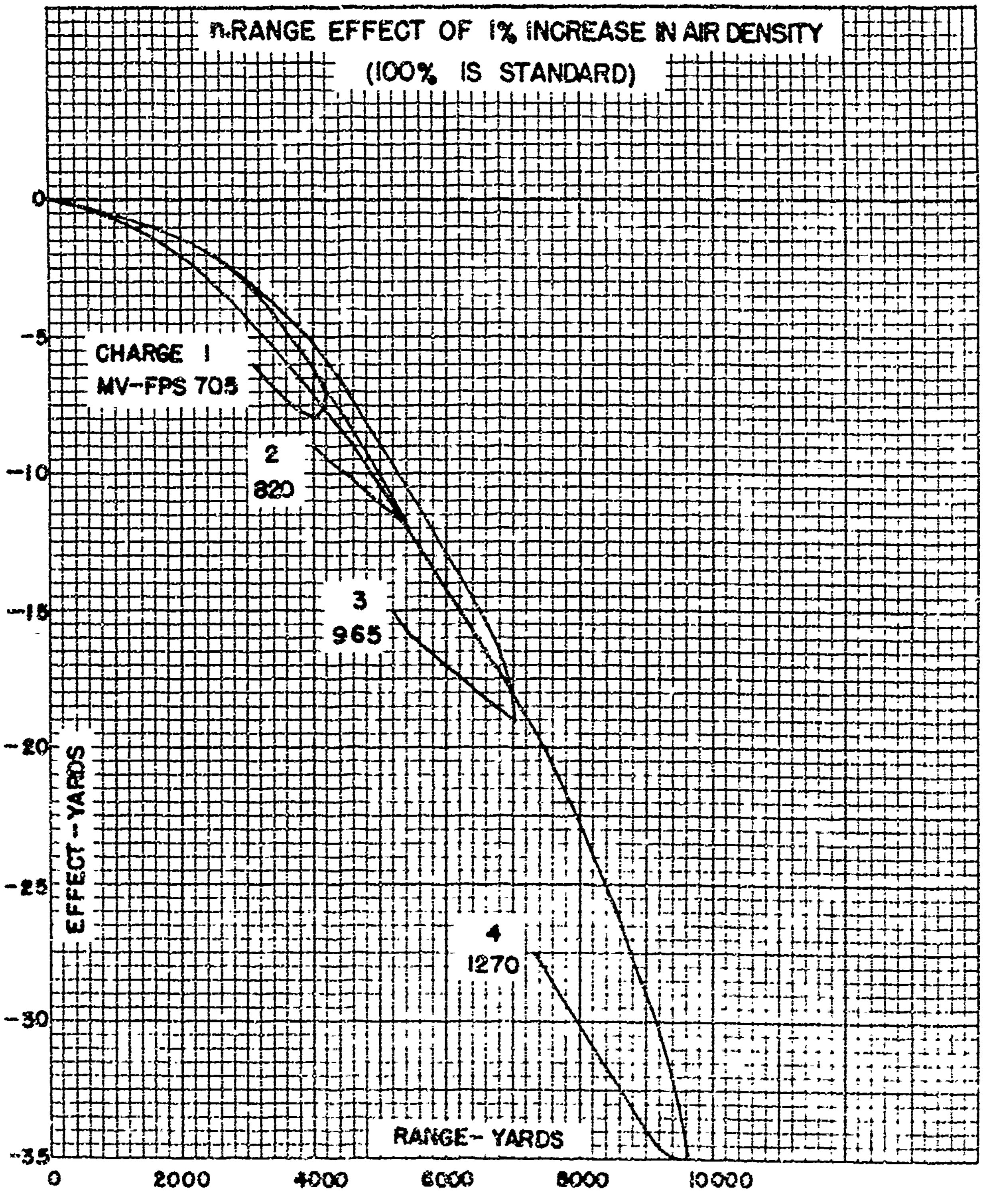

J RANGE EFFECT OF 1 ZONE INCREASE
IN WEIGHT OF PROJECTILE
(ZONE 2, MARKED ++, IS STANDARD)
n = -0.30
20
10
0
-10
-20
-30
-40
EFFECT — YARDS
0
2000
4000
6000
8000
10000
RANGE — YARDS
CHARGE 1
MV-FPS 705
2
820
3
965
4
1270

)


RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY
CHARGE 1
MV~FPS 705
2
820
3
965
4
1270
EFFECT - YARDS
RANGE - YARDS
0
2
4
6
8
10
12
0
2000
4000
6000
8000
10000


I. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE (59°F IS STANDARD)
EFFECT- YARDS
RANGE-YARDS
5
4
3
2
1
0
-1
0
2000
4000
6000
8000
10 000
CHARGE 1
MV-FPS 705
2
820
3
965
4
1270


mRANGE EFFECT OF 1 MPH REAR WIND
EFFECT - YARDS
RANGE- YARDS
0
2
4
6
8
10
12
14
16
0
2000
4000
6000
8000
10000
CHARGE 1
MV-FPS 705
2
820
3
965
4
1270


n-RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
CHARGE 1
MV-FPS 705
2
820
3
965
4
1270
EFFECT - YARDS
RANGE - YARDS
0
-5
-10
-15
-20
-25
-30
-35
0
2000
4000
6000
8000
10000

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 75-1-48

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
10 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 75-mm, M48, and M48E2
with
Fuzes, MT, M43; PD, M48A2, M51A4 and M57;
TSQ, M54 and M55A3; CP, M78; and VT, M97A1 and T73

Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 10
V	Effect data	11 - 14

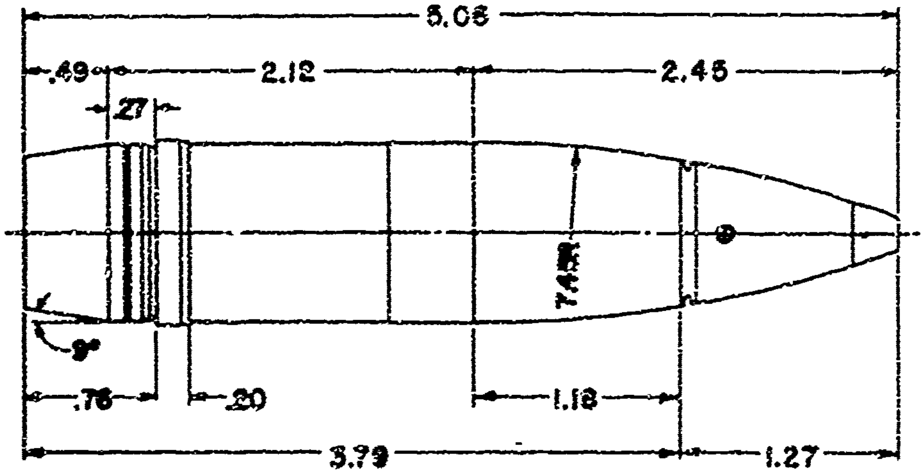
SECTION I

GENERAL

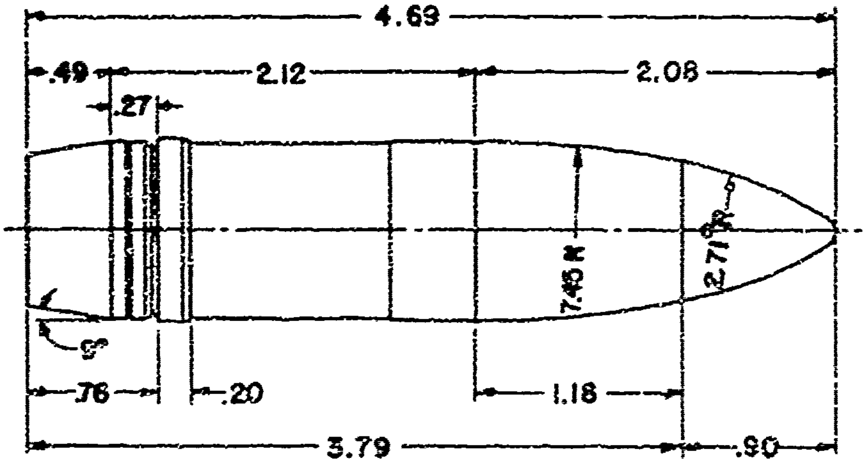
	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 75-mm High Explosive Shell M48 with the Mechanical Time Fuze M43, the Point Detonating Fuzes M48A2, M51A4 and M57, the Time and Super-quick Fuzes M54 and M55A3, the Concrete Piercing Fuze M78, and the Variable Time Fuze M97A1. It also includes some data regarding the experimental High Explosive Shell M48E2 and Variable Time Fuze T73. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 2.953"



SHELL, HE, 75-MM, M48
FUZE, PD, M48A2



SHELL, HE, 75-MM, M48
FUZE, CP, M78

SECTION II

DESCRIPTION

	Paragraph
Drawings -	2
Dimensions -	3
Physical characteristics -	4

2. Drawings.

Shell M48: Metal parts assembly, marking diagram and details	75-2-255
Booster M20: Assembly	73-2-112
Booster M21A4: Assembly	73-2-154
Fuze, MT, M43: Assembly	73-7- 29
Fuze, PD, M48A2: Assembly	73-2-140
Details	73-2-143, etc.
Fuze, PD, M51A4: Assembly	73-2-145
Details	73-2-143, etc.
Fuze, PD, M57: Assembly and details	73-2-138
Details	73-2-139
Fuze, TSQ, M54: Assembly	73-3-154
Details	73-3-156, 157, 158, 159, 160
Fuze, TSQ, M55A3: Assembly and details (The Booster M21A4 and the TSQ Fuze M54 are components of the TSQ Fuze M55A3)	73-3-155
Fuze, CP, M78: Body assembly and details	73-2-214

3. Dimensions.

Boattail:	Angle	9°00'
	Length	0.49 cal
Band.	Distance from boattail	0.27 cal
	Distance from base	0.76 cal
	Width	0.20 cal
Cylindrical body:	Length	2.12 cal
Ogive:	Length	1.16 cal
	Radius of arc	[illegible]
Shell; unfuzed:	Length	[illegible]
Fuze (any except CP, M78):	Outside length	
	Shell and Fuze	[illegible]
	Ogive and Fuze	2.4[illegible]

Fuze, CP, M78:	Outside length	0.90 cal
	Radius of arc	2.71 cal
	Shell and Fuze	4.69 cal
	Ogive and Fuze	2.08 cal

4. Physical characteristics.

Fuze	Mean Weight (lb) Zone 1	 2 (Standard)	 3	Base to Center of Gravity (cal)	Moments of Inertia (lb.ft^2) Axial	 Transverse
MT	14.40	14.70	15.00	2.043	0.1260	1.523
PD	14.40	14.70	15.00	2.037	0.1259	1.495
TSQ	14.40	14.70	15.00			
CP	15.12	15.42	15.72			
VT	14.65	14.95	15.25			

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses -	5
Theoretical yaw in bore -	6

5. Stresses. The following table and the graphical representation on page 5 show the longitudinal, radial and tangential stress at each of two sections: (A) the rear corner of the band seat and (B) the front of the band seat.

Gun	75-mm, M1897A1	
Twist of rifling	1/25.586	
Cross-sectional area of bore	6.967	sq in.
Rated maximum pressure	36,000	psi
Total weight of projectile	14.70	lb
Muzzle velocity	1,950	fps
Density of filler	0.057	lb per cu in.

Resultant Stress* 100 psi	Section A	 B
Longitudinal	- 203	- 410
Radial	+ 326	- 15
Tangential	605	+ 438

* + denotes tension, - denotes compression.

6. Theoretical yaw in bore.

Minimum	9 min
Maximum	13 min

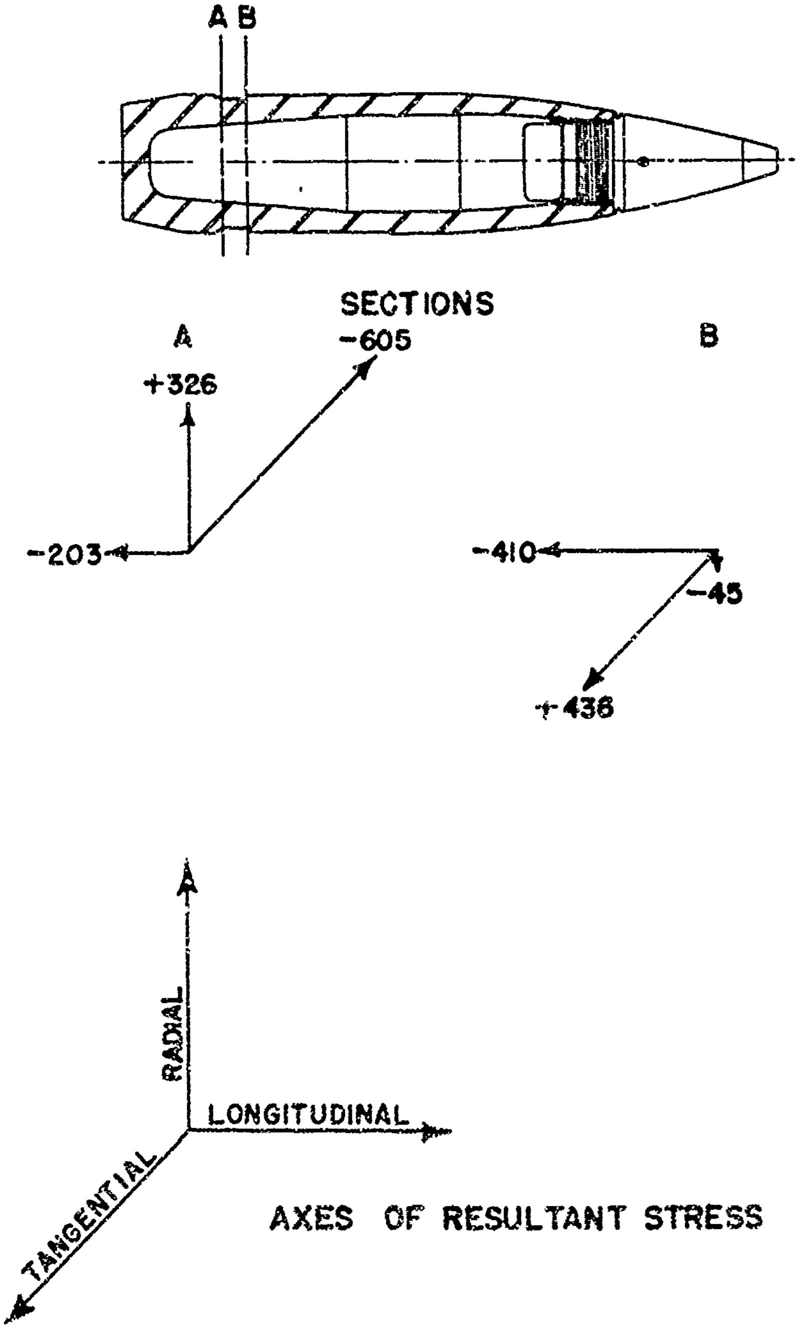


DIAGRAM OF RESULTANT STRESSES

SECTION IV

EXTERIOR BALLISTIC DATA

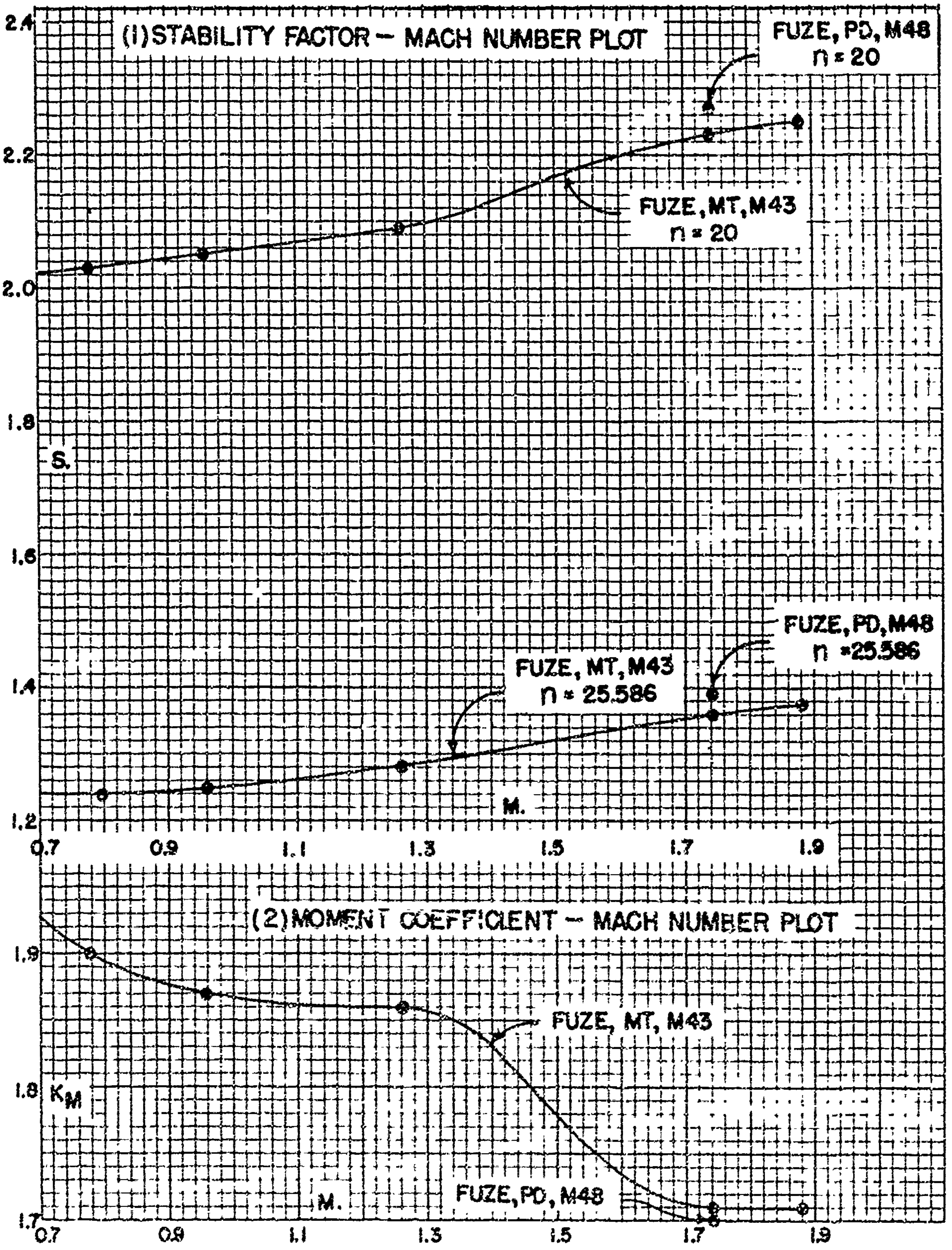
	Paragraph
Aerodynamic data -	7
Firing table data: Howitzers -	8
Firing table data: Tank Guns -	9
Firing table data: Aircraft Guns -	10

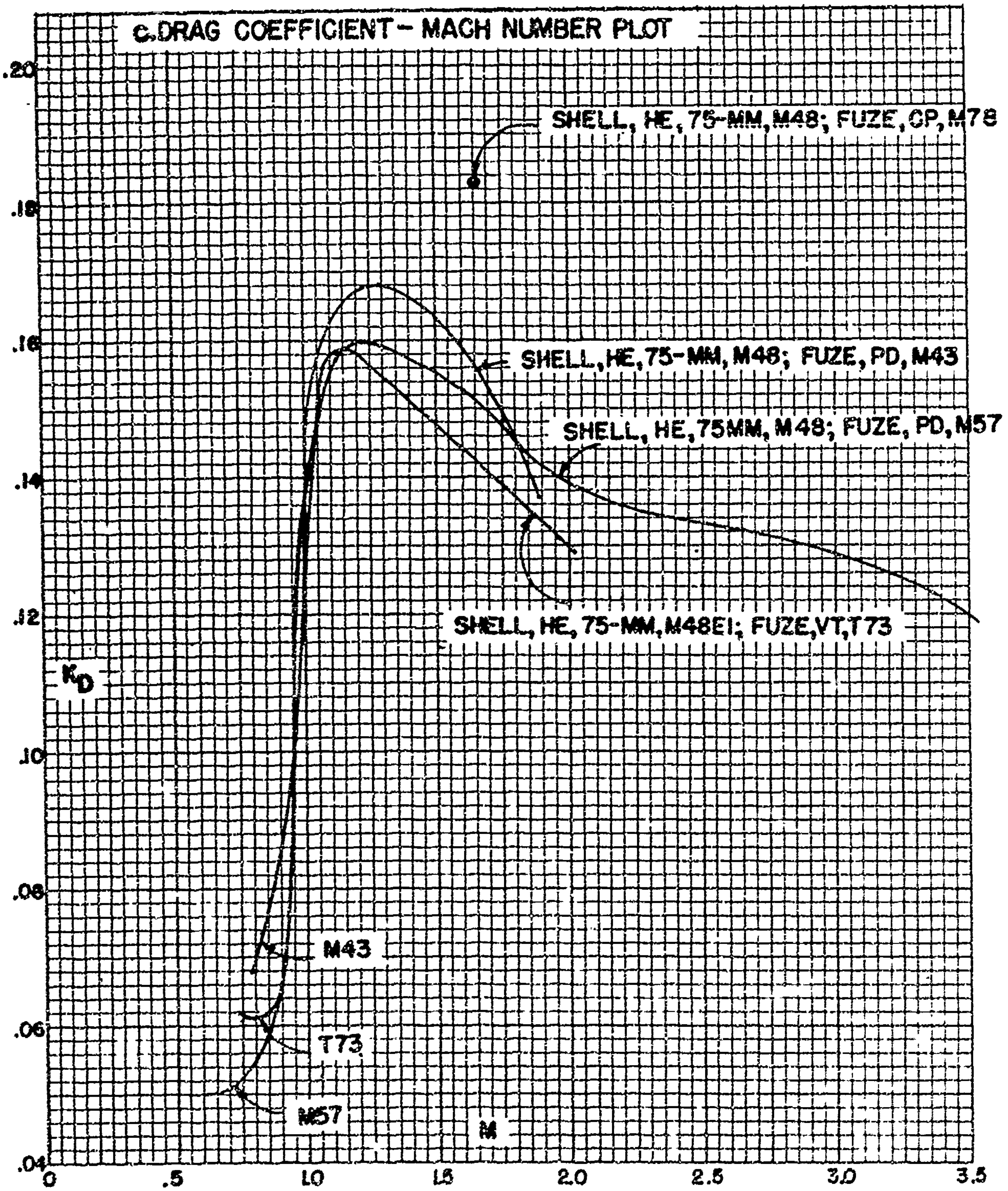
7. Aerodynamic data.

a. Loss of spin. Ballistic Research Laboratory Memorandum Report No. 297, "Spin Imparted by 75-mm Gun T13E1", gives data obtained by means of a radio spin sonde from five inert M48 Shell with a dummy fuze that has the same contour as the PD Fuze M48A2, fired from 75-mm Guns T13E1 with special tubes that have a French form of rifling with a twist of 1/22. The average muzzle velocity was 2014 fps. Below are average data for times of flight from 1 to 18 seconds:

Reynolds' number, based on the translational velocity and the caliber of the shell and the kinematic viscosity of the air	$2.30\text{x}10^6$
Axial couple coefficient, K_A	0.00587
Skin friction drag coefficient, C'_{DF}	0.00175

b. Stability. The "Report on Stability Firing with 75-mm T3 Shell Fitted with M39A2 PD and T12 Mechanical Time Fuzes" (Ordnance Program 4982, Technical Staff Test Program 1932-685) gives data on stability for the Shell M48 (T3) with the MT Fuze M43 (T12) at muzzle velocities of 905, 1113, 1479, and 2190 fps. The report on "Stability and Damping of 75-mm HE Shell M48" (Ballistic Research Laboratory Memorandum Report No. 203) gives data on stability for the Shell M48 with the MT Fuze M43A3 and the PD Fuze M48 at a muzzle velocity of about 1950 fps. The stability firings were done with the 75-mm Gun M1920 MVI No. 1, which was rifled with a twist of 1/25, and a modified Aircraft Gun M4 with a twist of 1/22. The twist of rifling is 1/20 for the 75-mm Howitzers, 1/22 for the Aircraft Guns M5A1 and M10, and 1/25.586 (corresponding to an angle of 7°) for the Tank Guns M3, M6 and M17 and the Antiaircraft Guns T6 and T22.


(1) STABILITY FACTOR — MACH NUMBER PLOT
FUZE, PD, M48
n = 20
FUZE, MT, M43
n = 20
FUZE, PD, M48
n = 25.586
FUZE, MT, M43
n = 25.586
S.
M.
2.4
2.2
2.0
1.8
1.6
1.4
1.2
0.7
0.9
1.1
1.3
1.5
1.7
1.9
(2) MOMENT COEFFICIENT — MACH NUMBER PLOT
FUZE, MT, M43
FUZE, PD, M48
K_M
M.
1.9
1.8
1.7
0.7
0.9
1.1
1.3
1.5
1.7
1.9

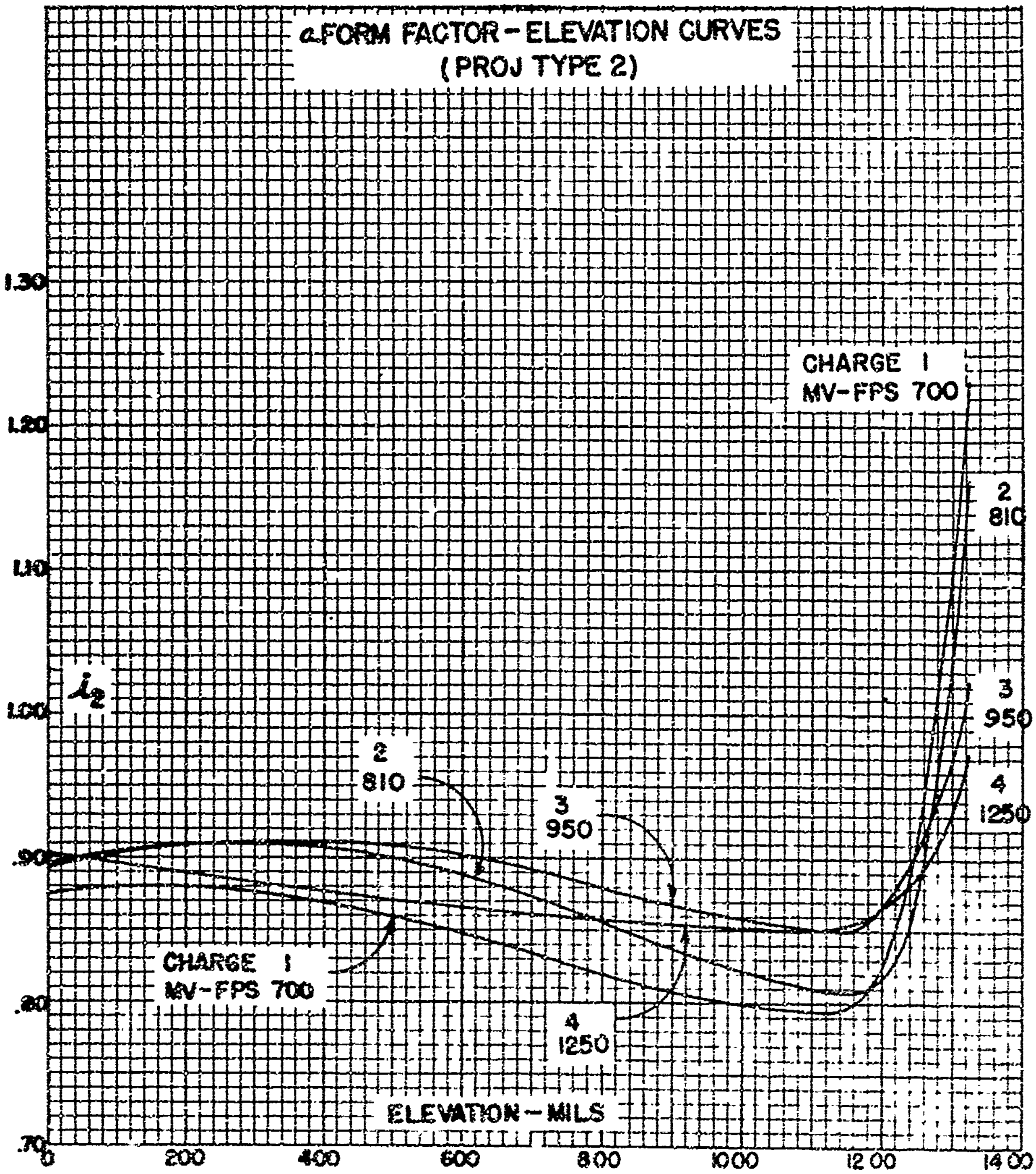

c. DRAG COEFFICIENT – MACH NUMBER PLOT
SHELL, HE, 75-MM, M48; FUZE, CP, M78
SHELL, HE, 75-MM, M48; FUZE, PD, M43
SHELL, HE, 75MM, M48; FUZE, PD, M57
SHELL, HE, 75-MM, M48E1; FUZE, VT, T73
M43
T73
M57
K_D
M
.20
.18
.16
.14
.12
.10
.08
.06
.04
0
.5
1.0
1.5
2.0
2.5
3.0
3.5

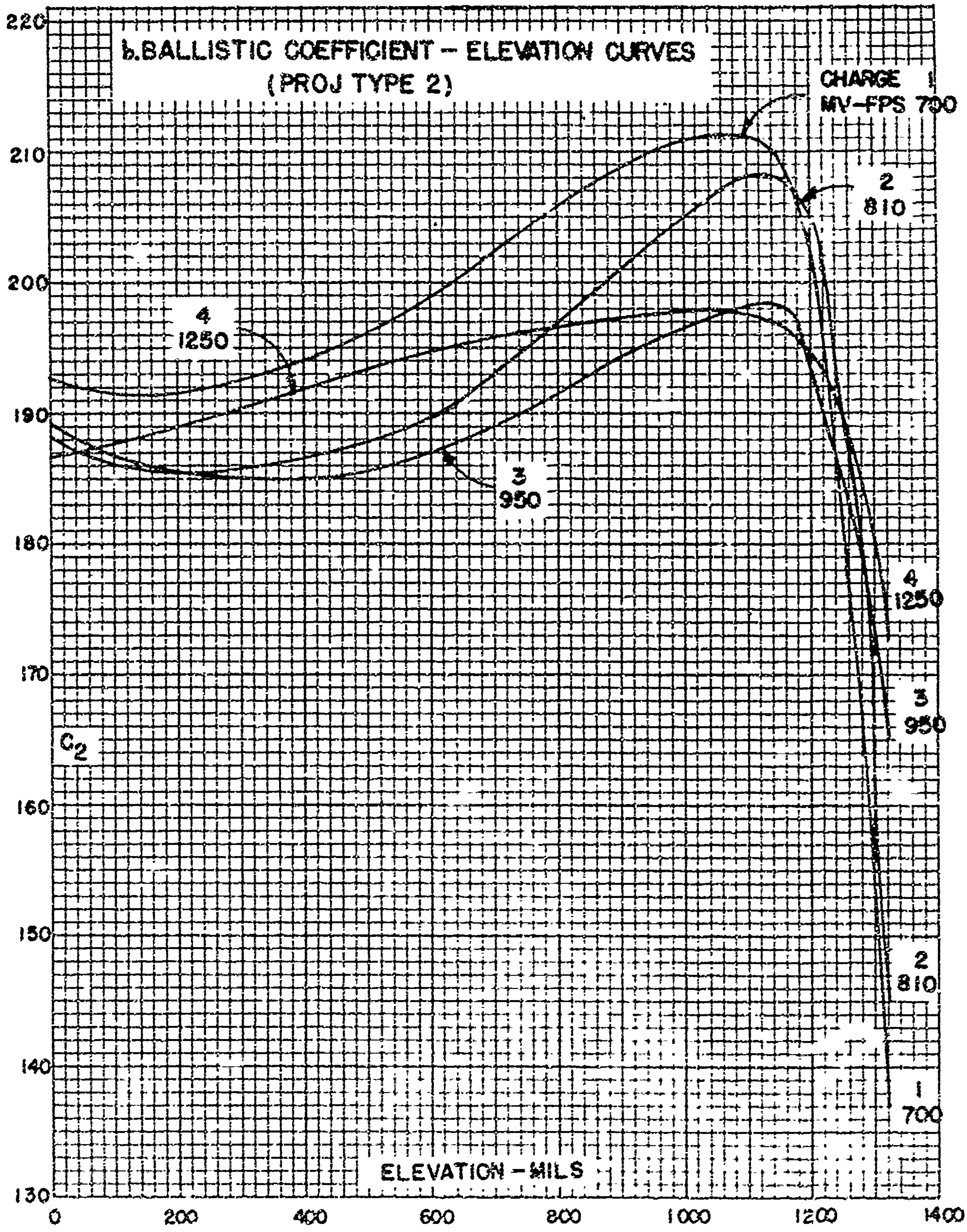
d. Damping. The damping of the M48 Shell was observed in connection with the stability firings at 1950 fps. The average values of the sum of the yawing moment damping factor f and the cross wind force damping factor κ are tabulated below.

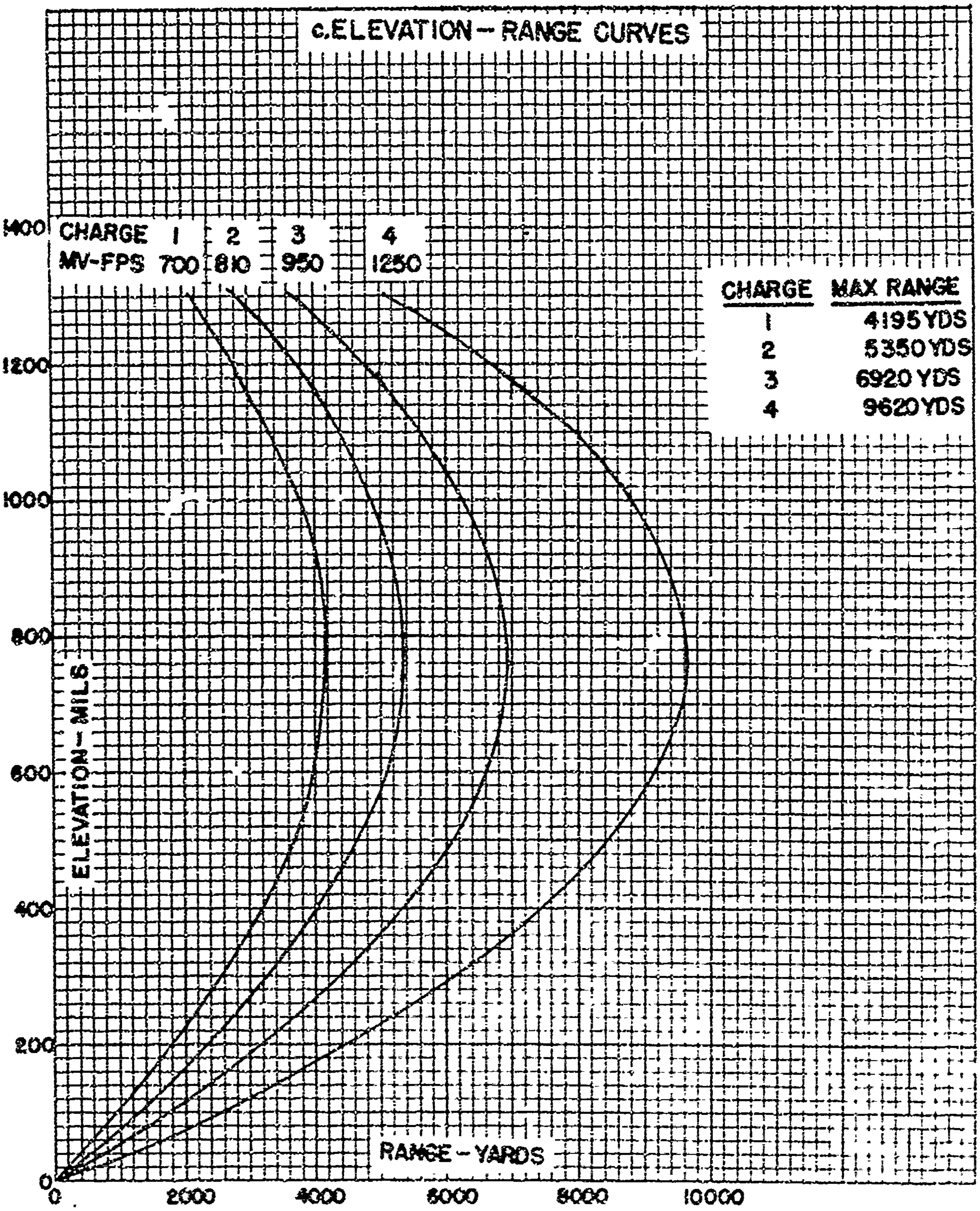
Fuze	$f + \kappa$	Probable Error
MT, M43A3	2.82	0.49
PD, M48	5.00	1.08
Both	3.76	0.77

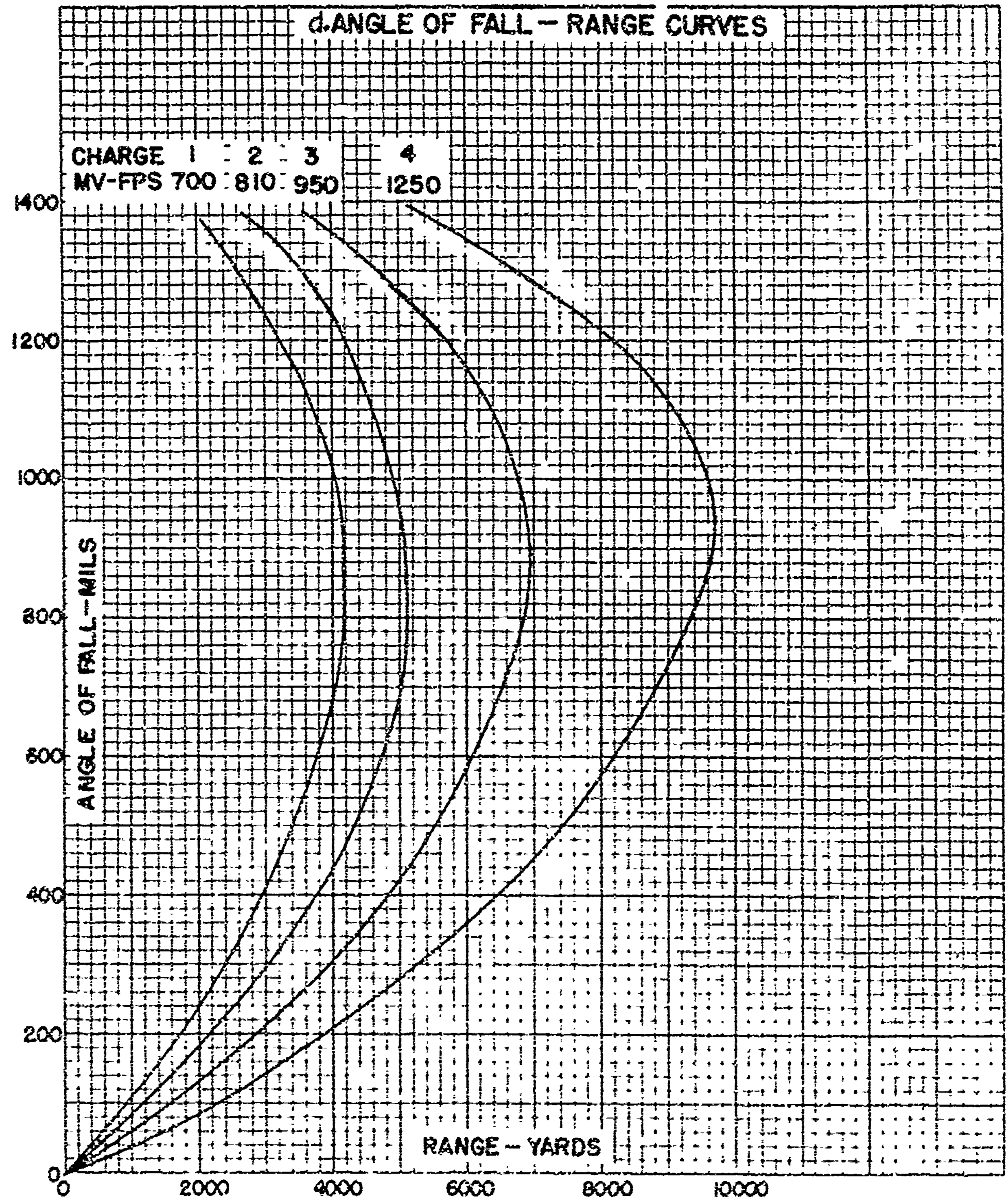
8. Firing table data: Howitzers. FT 75-I-4 with C5.

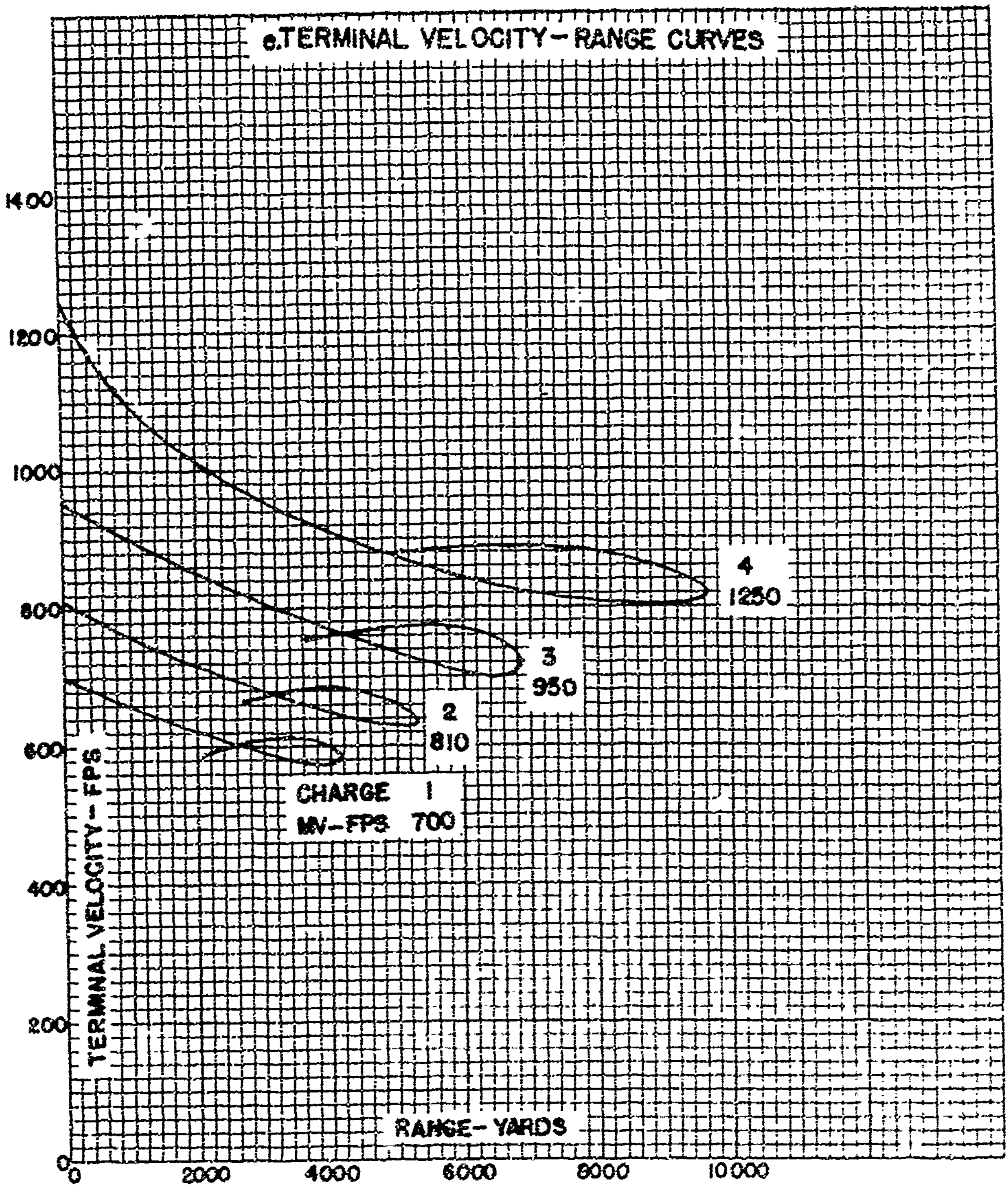
Howitzers, 75-mm, M1A1, M2 and M3. Twist of rifling: 1/20. OCM items 15055 and 15132 recommended and approved standardization of the HE Shell M48 for use in the Field Gun. OCM items 15194 and 15278 recommended and approved standardization of the HE Shell M48 for use in the Howitzer.

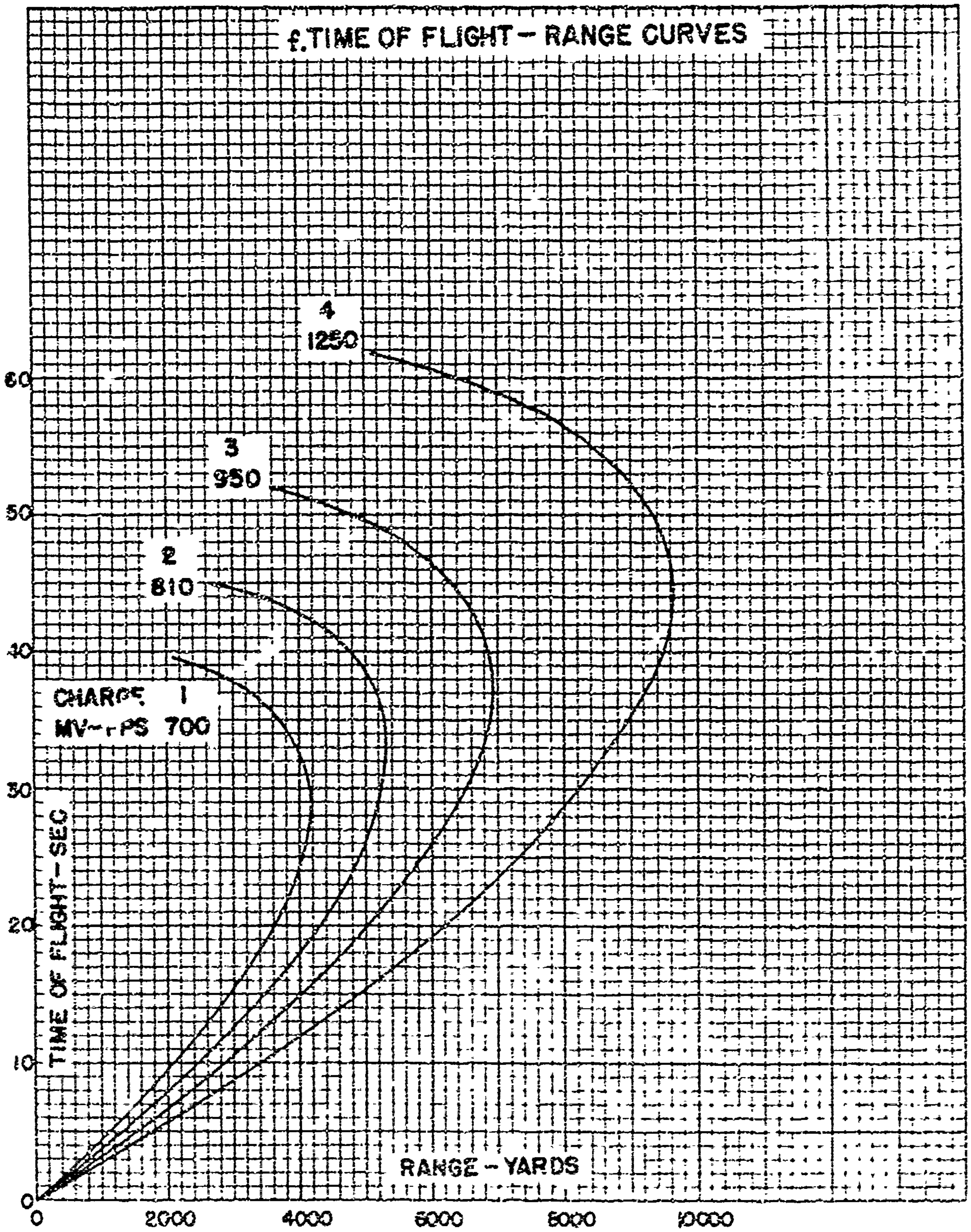

a FORM FACTOR - ELEVATION CURVES
(PROJ TYPE 2)
i_2
1.30
1.20
1.10
1.00
.90
.80
.70
0
200
400
600
800
1000
1200
1400
ELEVATION - MILS
CHARGE 1
MV-FPS 700
2
810
3
950
4
1250
2
810
3
950
CHARGE 1
MV-FPS 700
4
1250

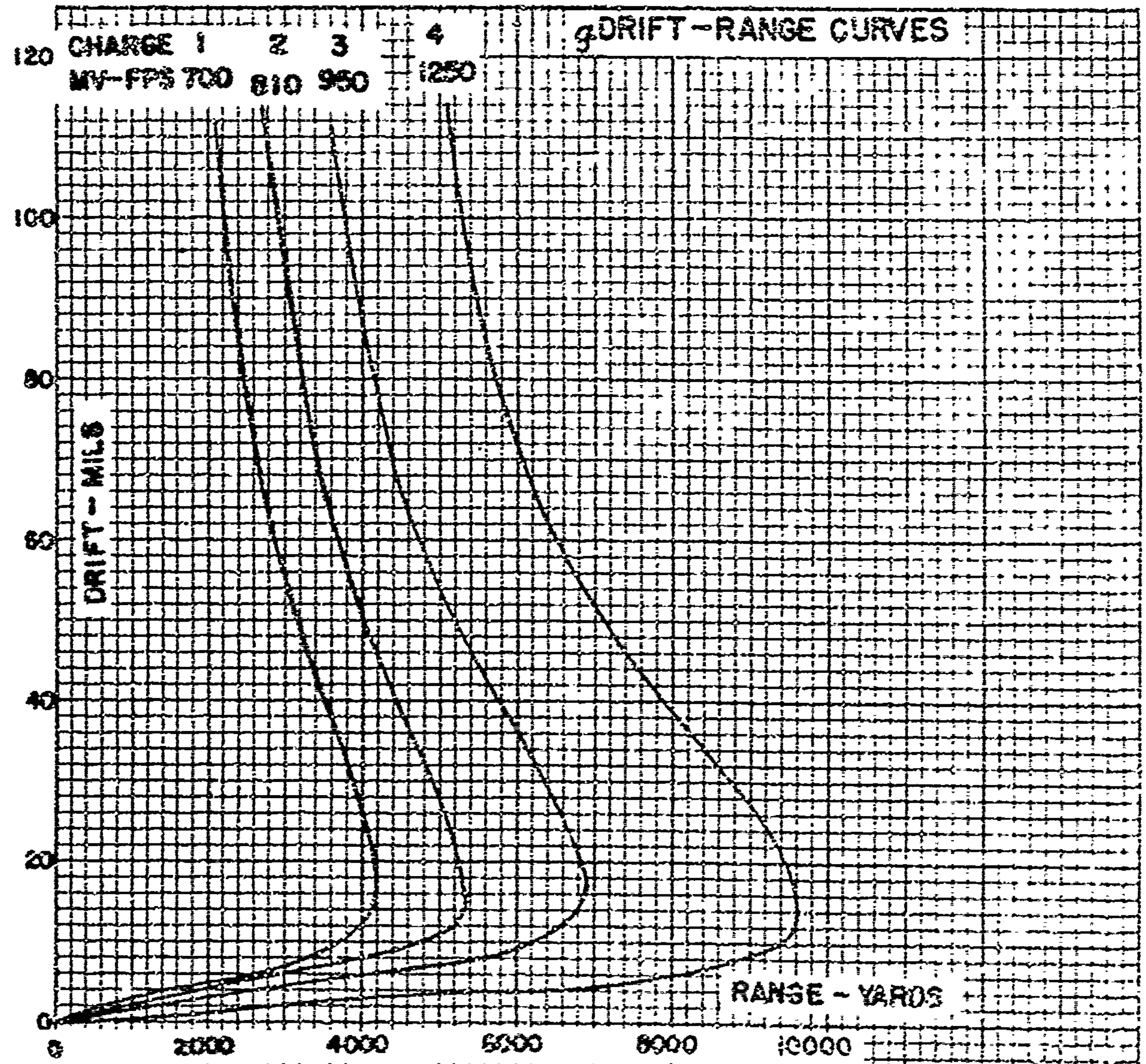

b.BALLISTIC COEFFICIENT – ELEVATION CURVES
(PROJ TYPE 2)
CHARGE 1
MV–FPS 700
2
810
4
1250
3
950
4
1250
3
950
2
810
1
700
C2
ELEVATION – MILS
220
210
200
190
180
170
160
150
140
130
0
200
400
600
800
1000
1200
1400


c. ELEVATION — RANGE CURVES
CHARGE 1 2 3 4
MV-FPS 700 810 950 1250
CHARGE MAX RANGE
1 4195 YDS
2 5350 YDS
3 6920 YDS
4 9620 YDS
ELEVATION — MILS
0
200
400
600
800
1000
1200
1400
RANGE — YARDS
0
2000
4000
6000
8000
10000

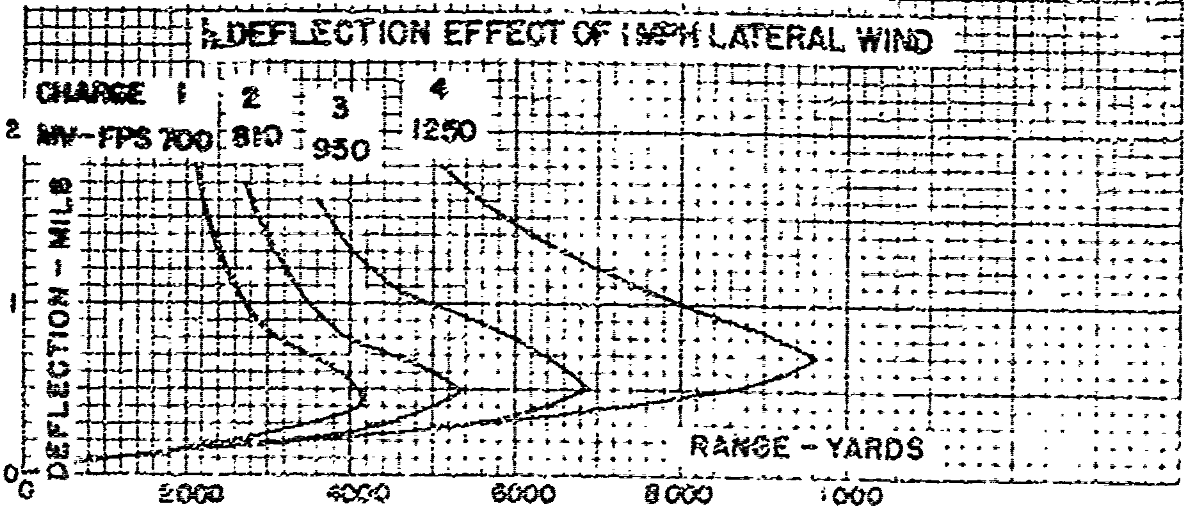

d. ANGLE OF FALL — RANGE CURVES
CHARGE 1 2 3 4
MV-FPS 700 810 950 1250
ANGLE OF FALL — MILS
0
200
400
600
800
1000
1200
1400
RANGE — YARDS
0
2000
4000
6000
8000
10000


e.TERMINAL VELOCITY—RANGE CURVES
TERMINAL VELOCITY—FPS
RANGE—YARDS
0
200
400
600
800
1000
1200
1400
0
2000
4000
6000
8000
10000
CHARGE 1
MV—FPS 700
2
810
3
950
4
1250

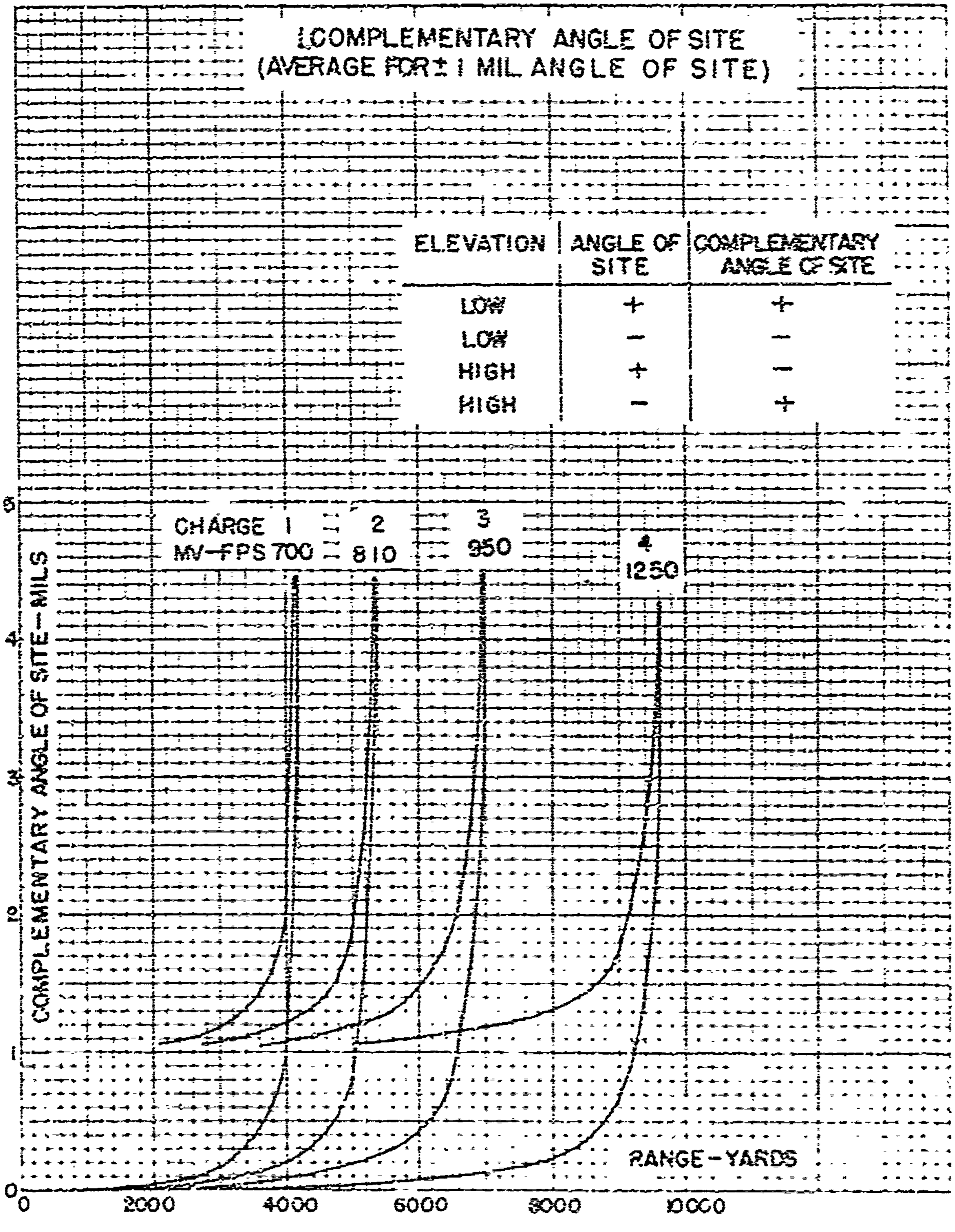

f. TIME OF FLIGHT – RANGE CURVES
4
1250
3
950
2
810
CHARGE 1
MV–FPS 700
TIME OF FLIGHT – SEC
0
10
20
30
40
50
60
RANGE – YARDS
0
2000
4000
6000
8000
10000



g. DRIFT—RANGE CURVES

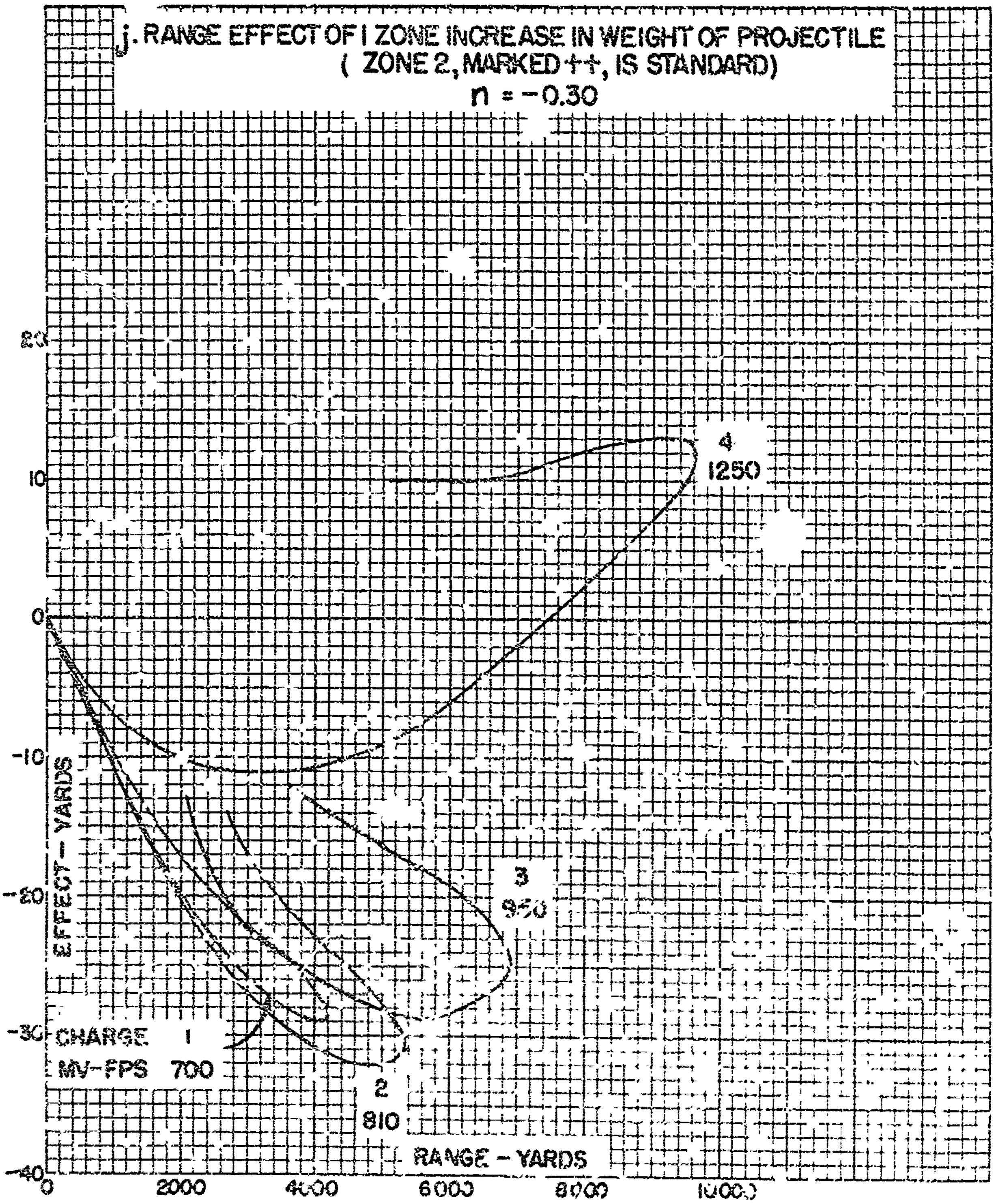


h. DEFLECTION EFFECT OF 1 MPH LATERAL WIND

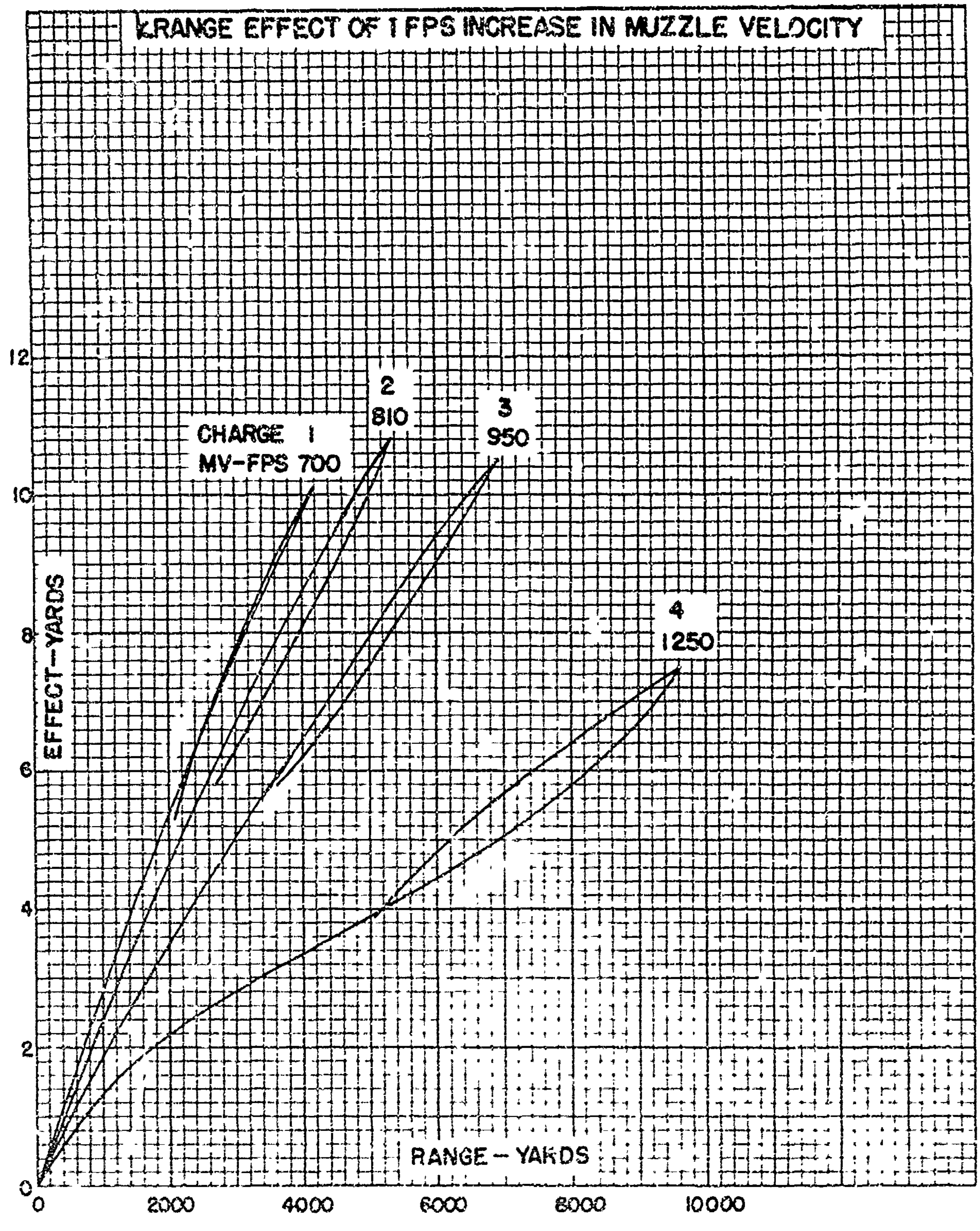


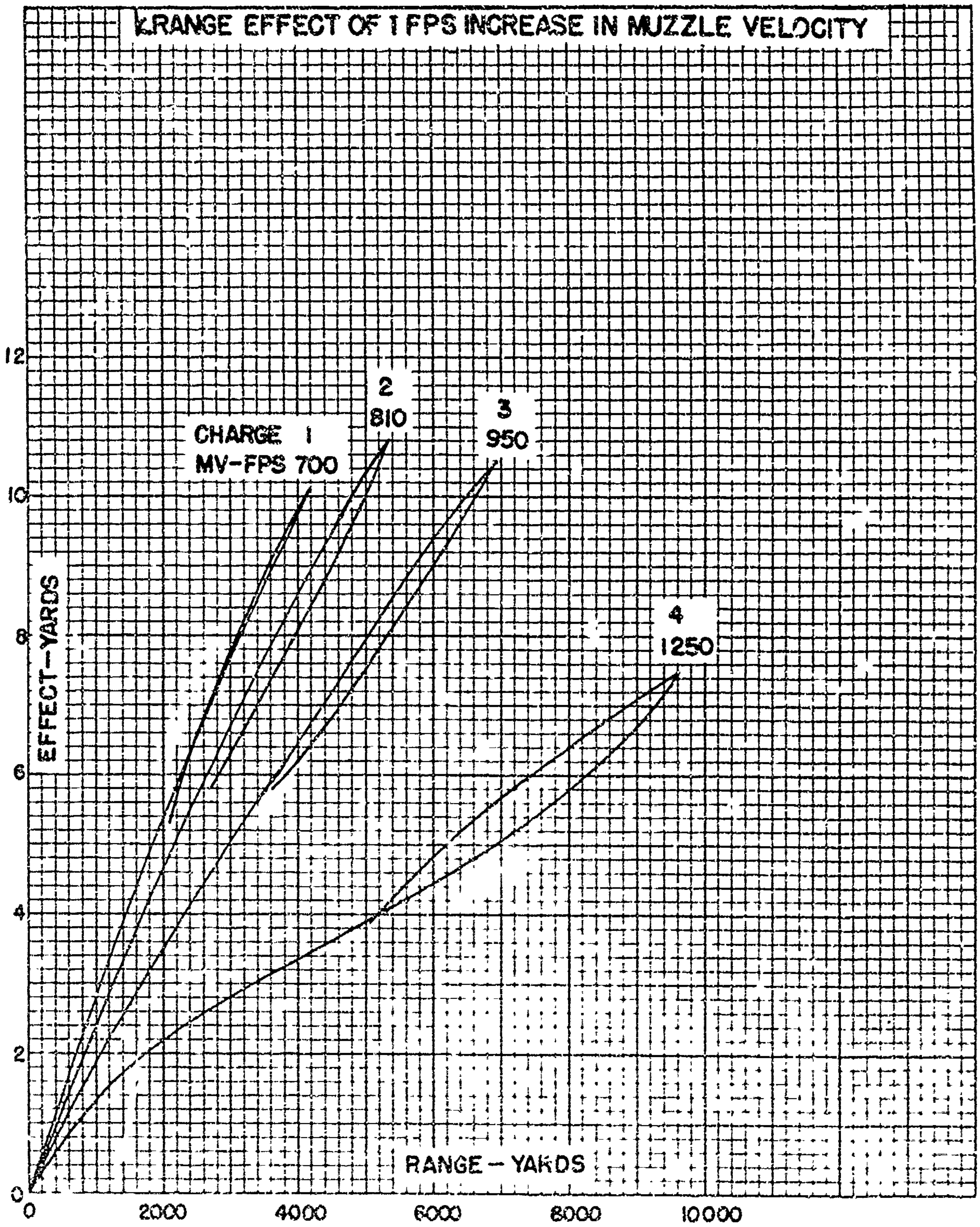
COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± 1 MIL ANGLE OF SITE)

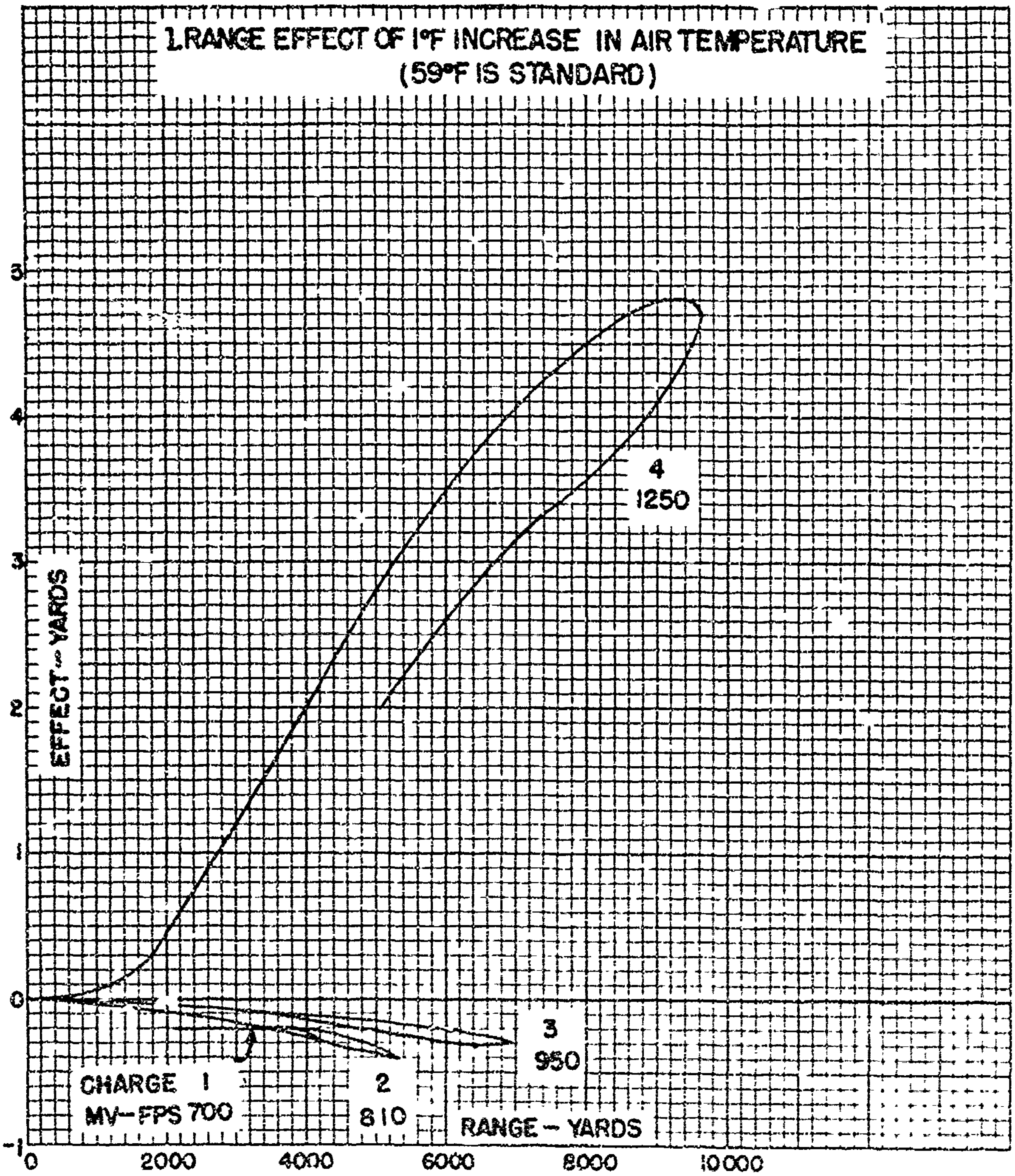
ELEVATION	ANGLE OF SITE	COMPLEMENTARY ANGLE OF SITE
LOW	+	+
LOW	−	−
HIGH	+	−
HIGH	−	+

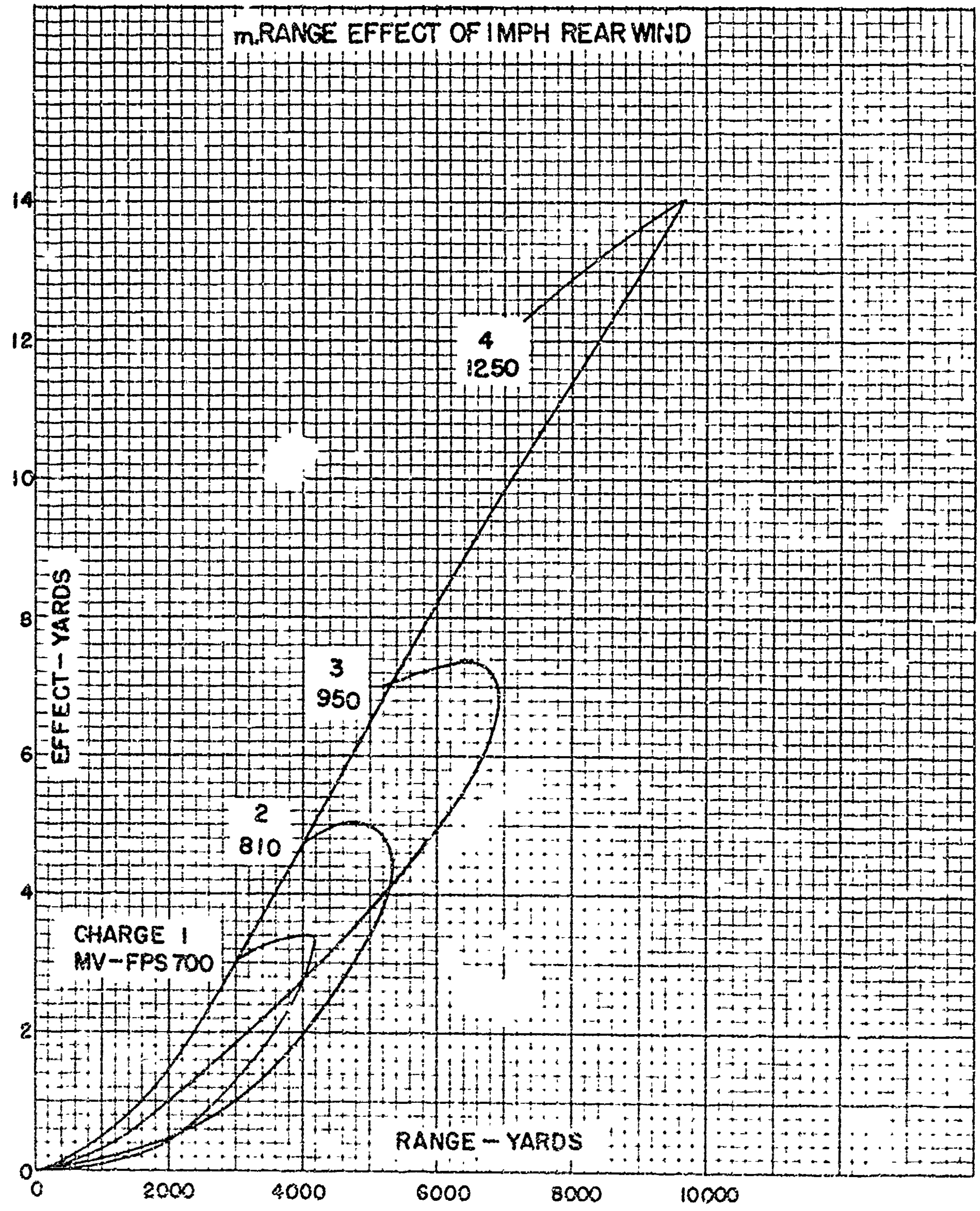


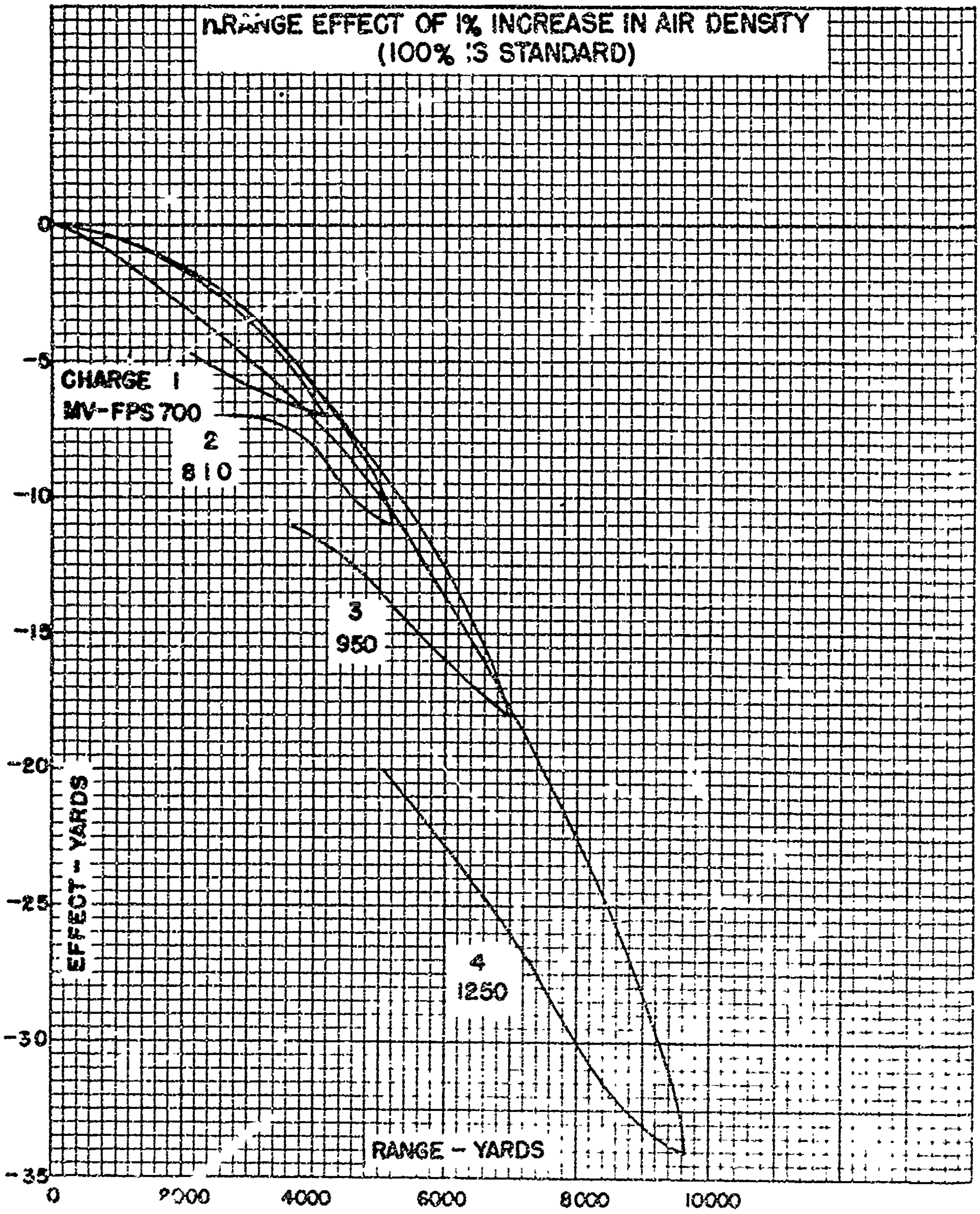
j. RANGE EFFECT OF 1 ZONE INCREASE IN WEIGHT OF PROJECTILE
(ZONE 2, MARKED ††, IS STANDARD)
n = −0.30

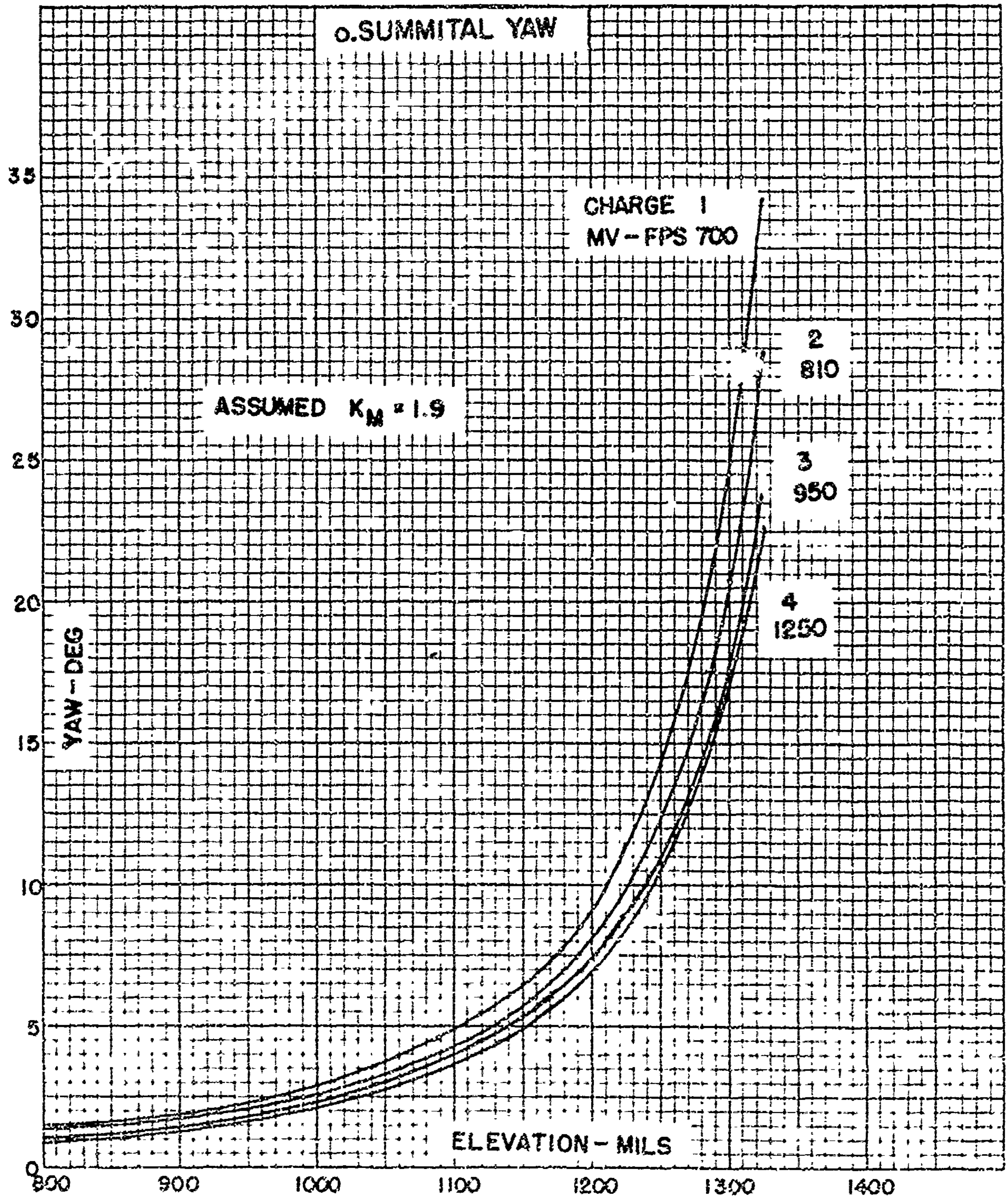

RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY
EFFECT—YARDS
RANGE — YARDS
CHARGE 1
MV-FPS 700
2
810
3
950
4
1250
0
2
4
6
8
10
12
0
2000
4000
6000
8000
10000


RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY
CHARGE 1
MV-FPS 700
2
810
3
950
4
1250
EFFECT—YARDS
RANGE — YARDS
0
2
4
6
8
10
12
0
2000
4000
6000
8000
10000


1. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE
(59°F IS STANDARD)
EFFECT — YARDS
RANGE — YARDS
CHARGE 1
MV—FPS 700
2
810
3
950
4
1250
5
4
3
2
1
0
-1
0
2000
4000
6000
8000
10000


m. RANGE EFFECT OF 1 MPH REAR WIND
EFFECT - YARDS
RANGE - YARDS
0
2
4
6
8
10
12
14
0
2000
4000
6000
8000
10000
CHARGE 1
MV-FPS 700
2
810
3
950
4
1250

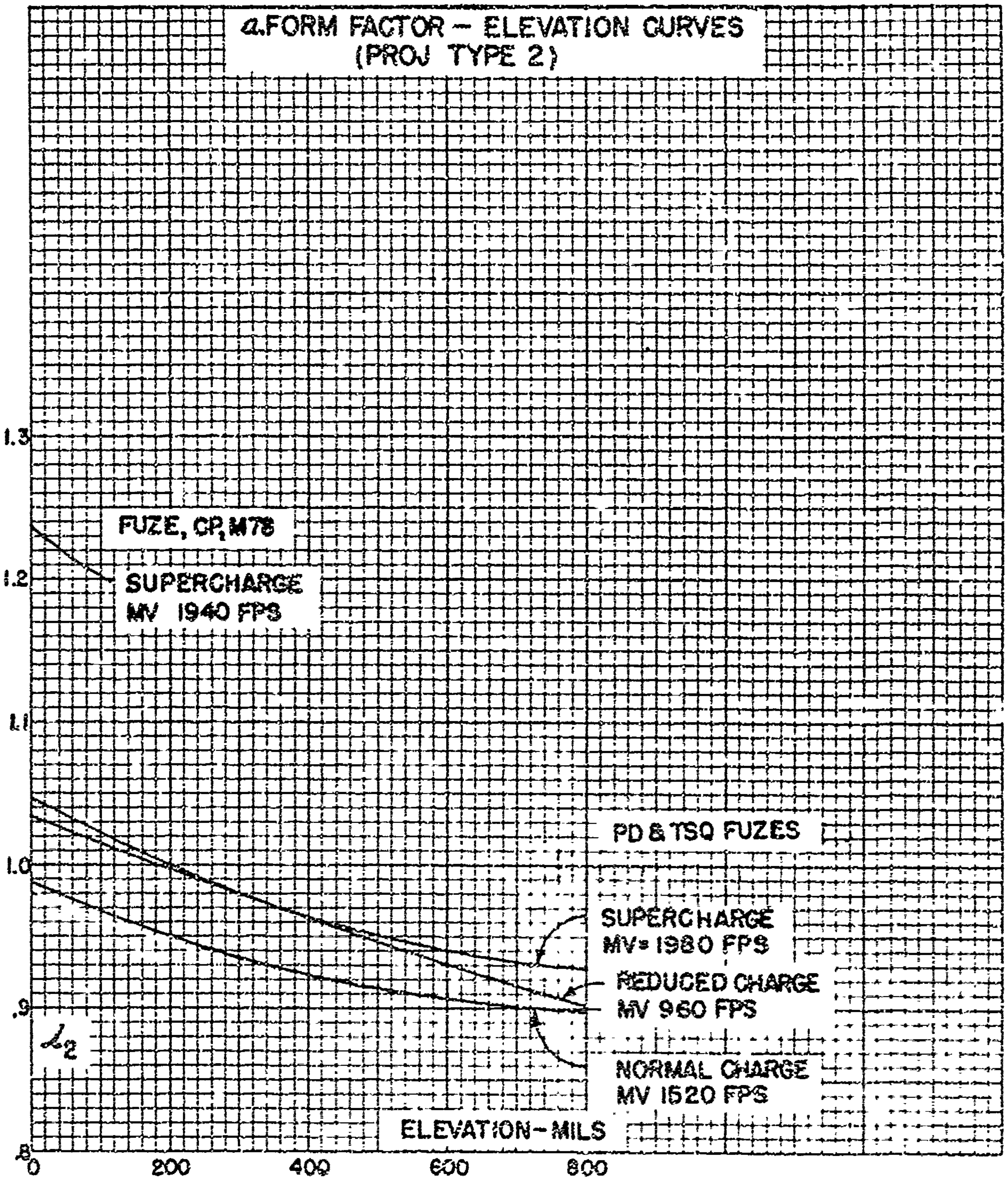

RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
CHARGE 1
MV-FPS 700
2
810
3
950
4
1250
EFFECT - YARDS
RANGE - YARDS
0
-5
-10
-15
-20
-25
-30
-35
0
2000
4000
6000
8000
10000


o.SUMMITAL YAW
CHARGE 1
MV-FPS 700
2
810
3
950
4
1250
ASSUMED K_M = 1.9
YAW-DEG
ELEVATION-MILS
0
5
10
15
20
25
30
35
800
900
1000
1100
1200
1300
1400

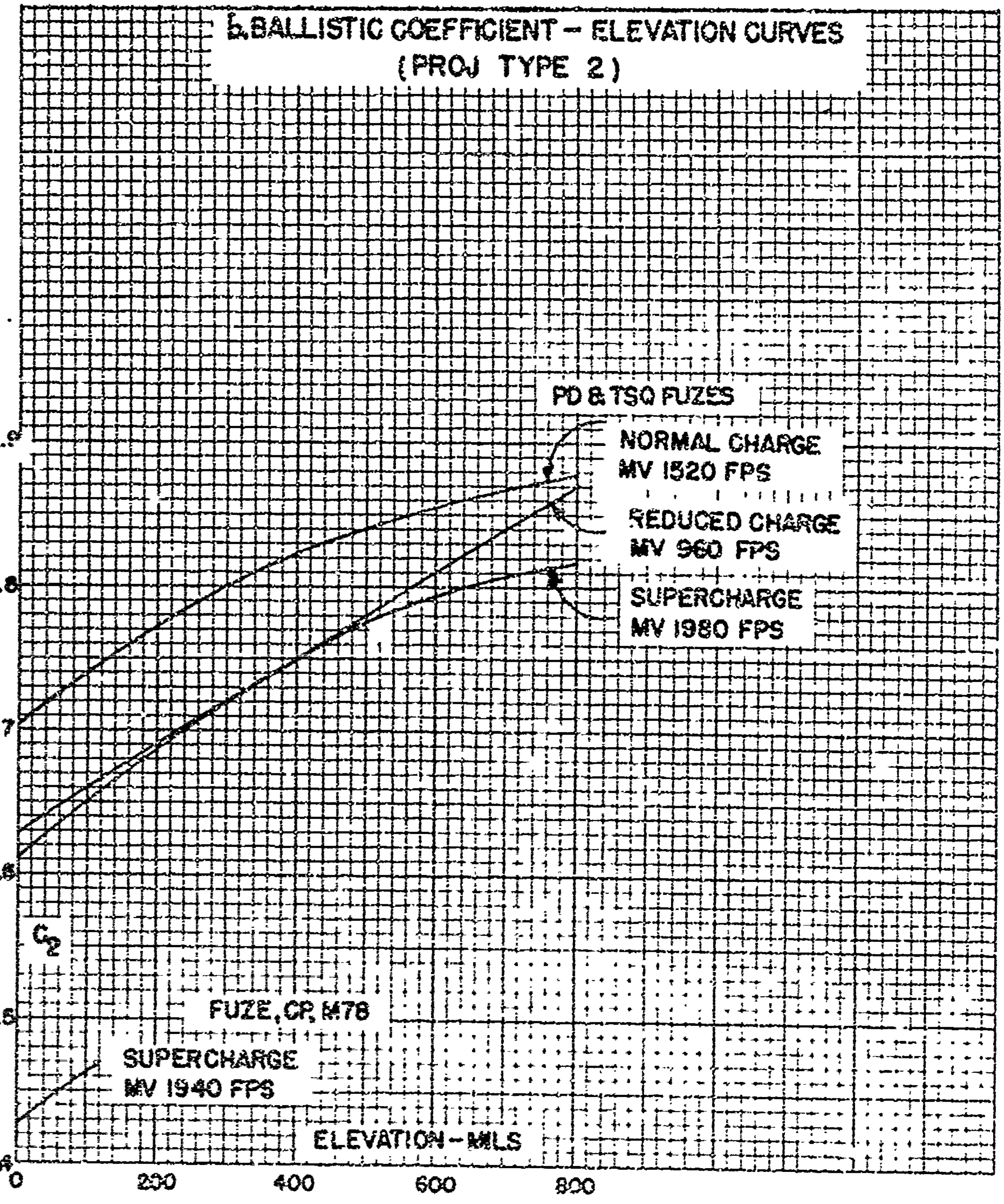
9. Firing table data: Tank Guns. FT 75-AY-1.

Guns, 75-mm, M3 (mounted in Medium Tank M4 and modification, including Assault Tank M4A3E2) M6 and M17 (mounted in Light Tank M24). Twist of rifling: 1/25.586.

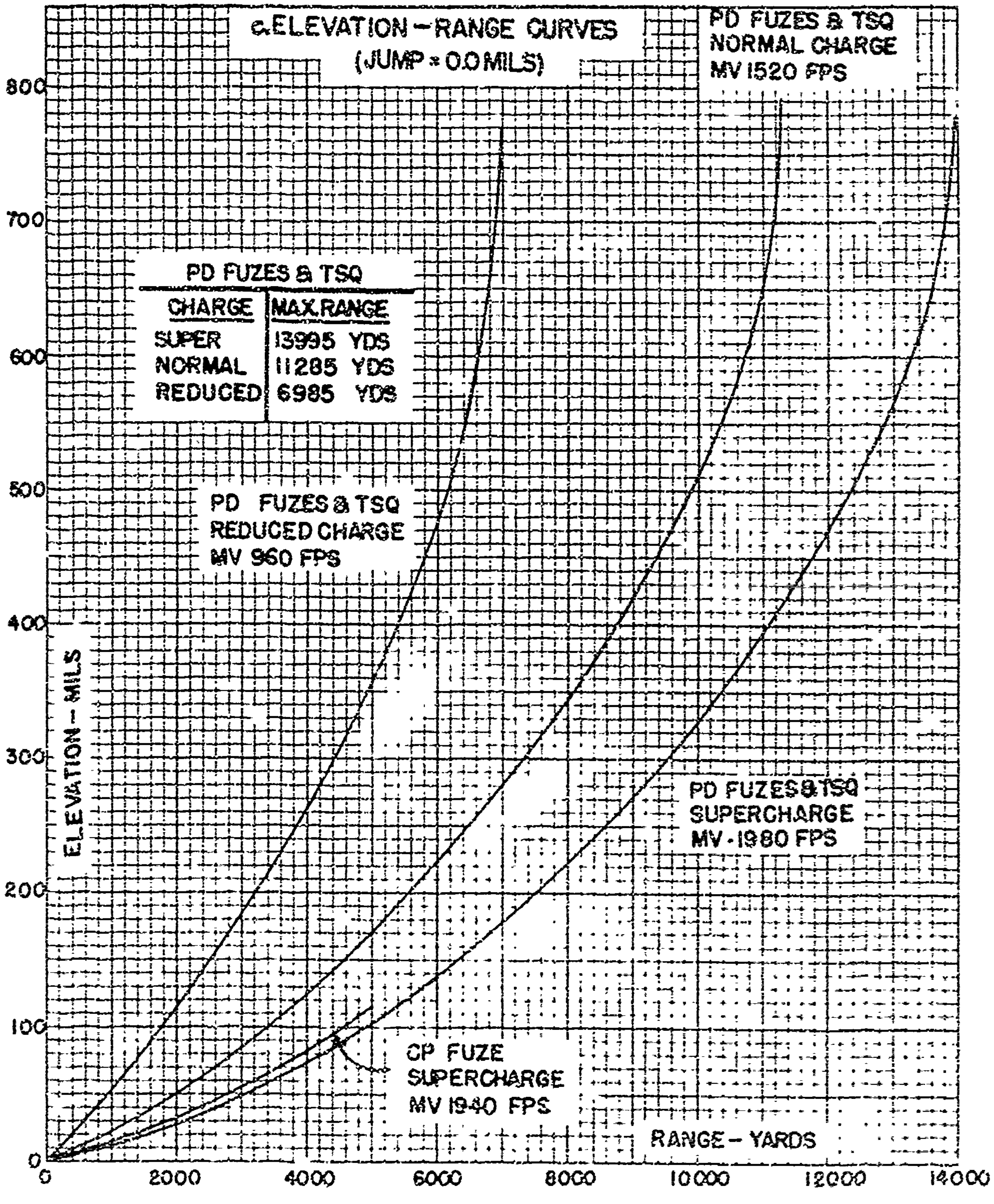
OCM items 16640 and 16741 recommended and approved the use of the HE Shell M48 in the 75-mm Tank Gun M2, which is now obsolete.



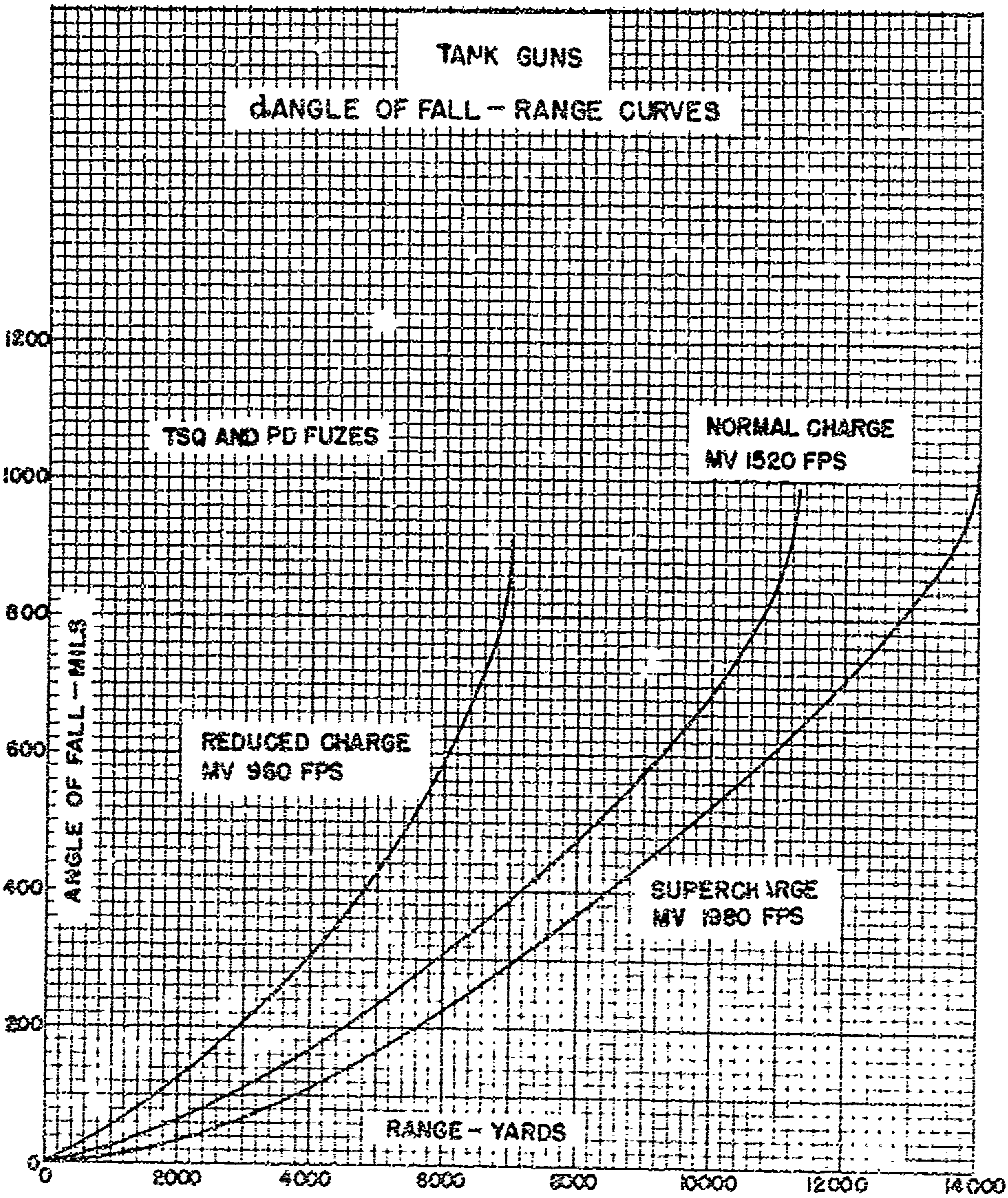
a. FORM FACTOR – ELEVATION CURVES
(PROJ TYPE 2)

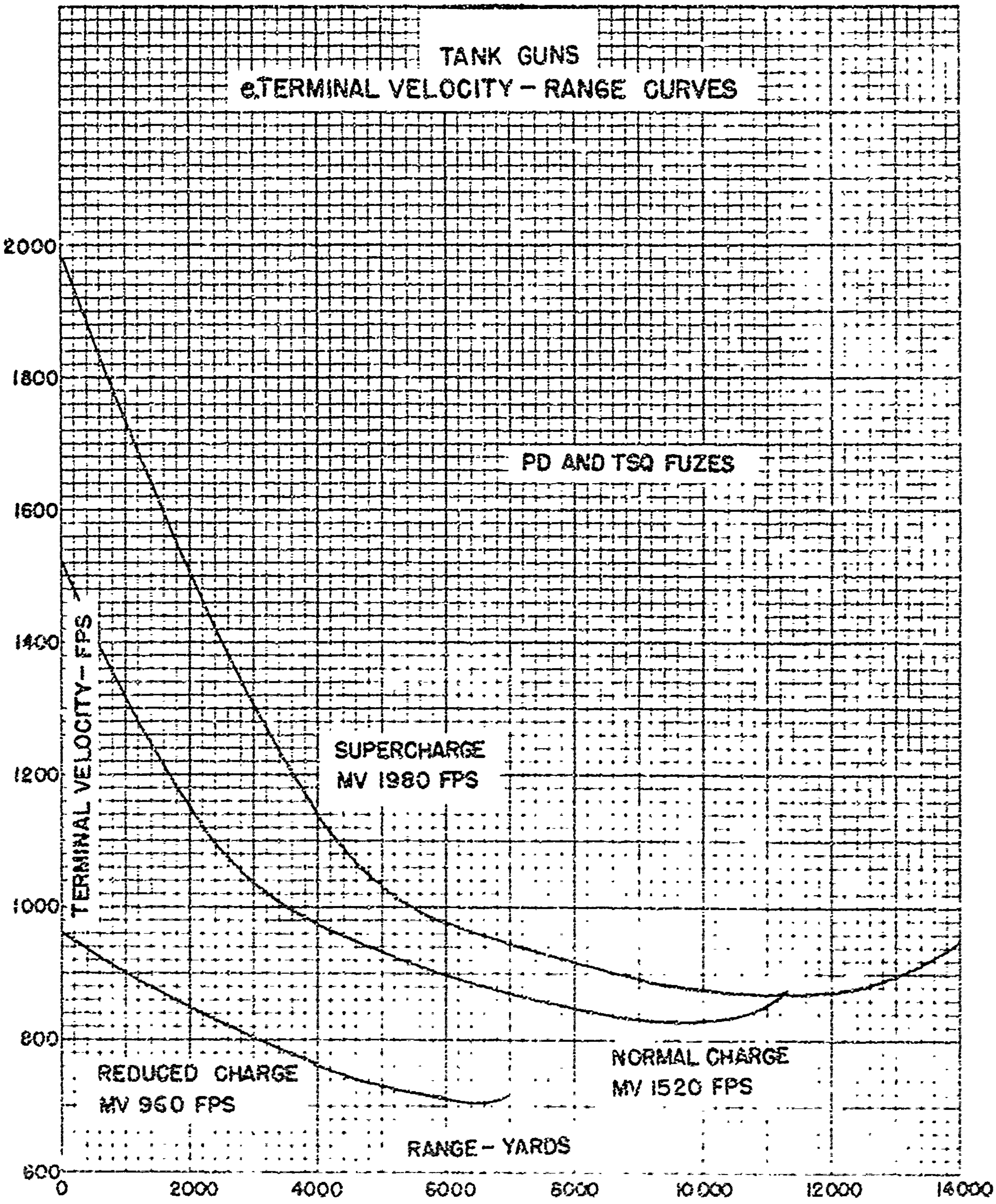


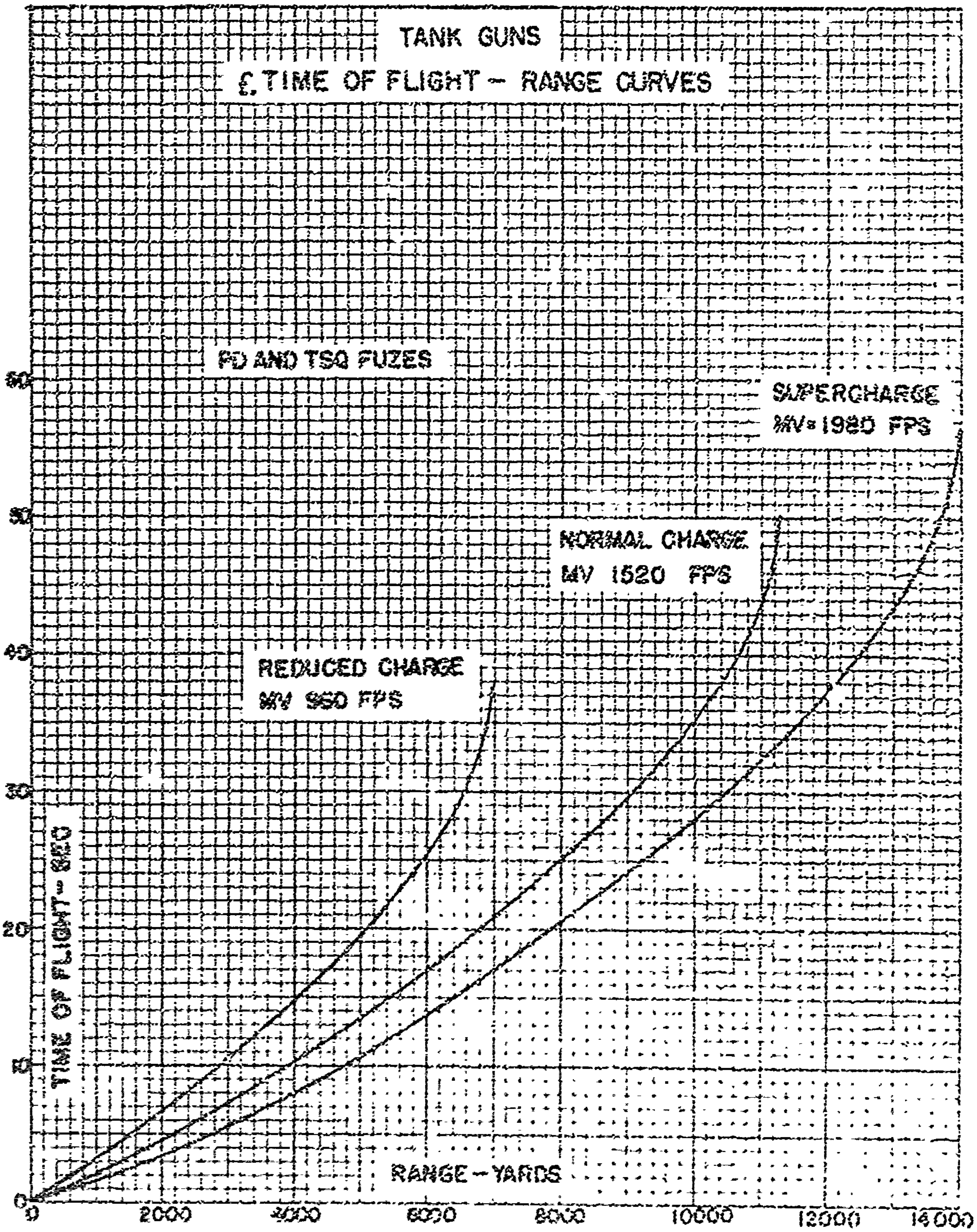
b. BALLISTIC COEFFICIENT – ELEVATION CURVES
(PROJ TYPE 2)

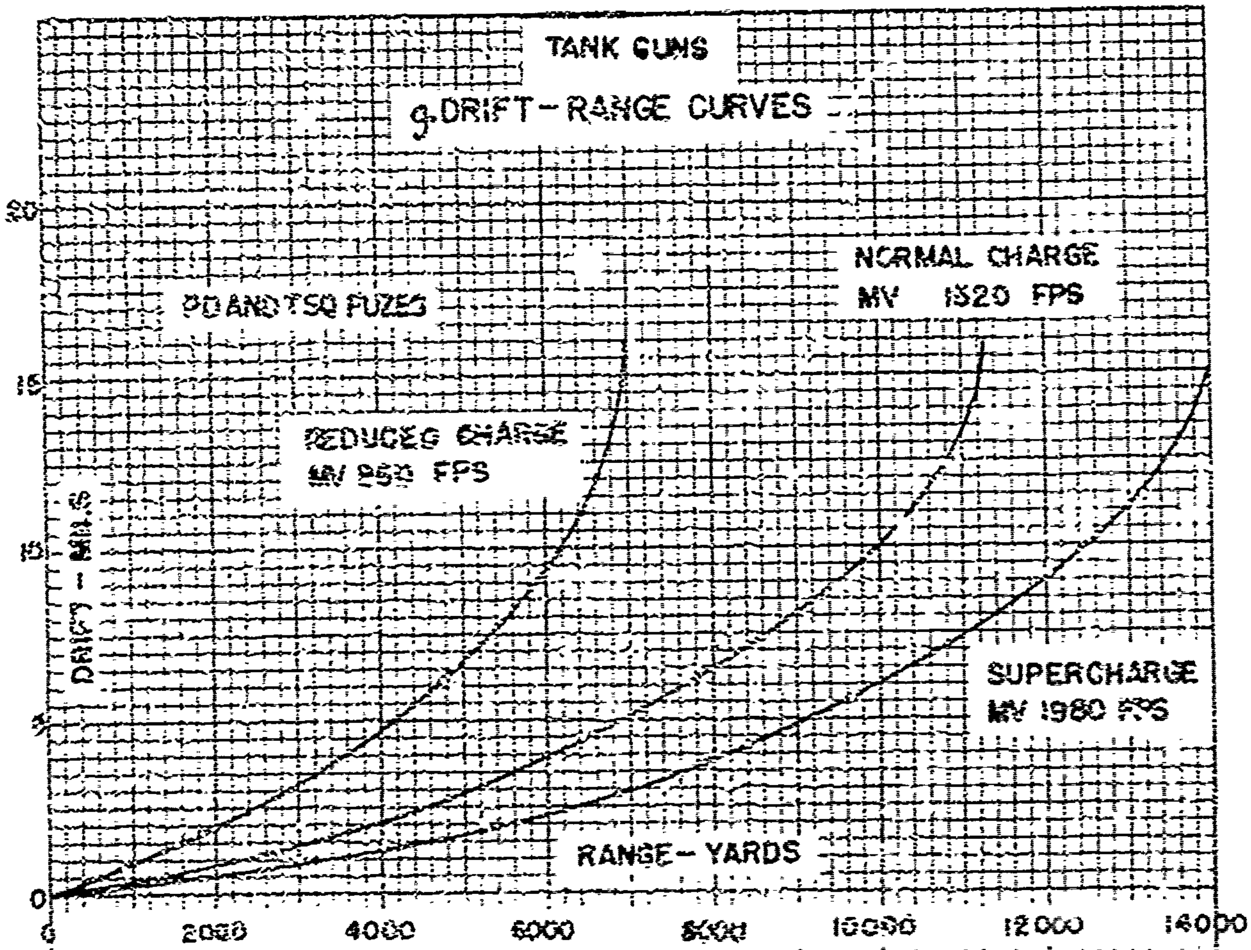

c. ELEVATION – RANGE CURVES
(JUMP = 0.0 MILS)
PD FUZES & TSQ NORMAL CHARGE MV 1520 FPS
PD FUZES & TSQ
CHARGE | MAX. RANGE
SUPER 13995 YDS
NORMAL 11285 YDS
REDUCED 6985 YDS
PD FUZES & TSQ REDUCED CHARGE MV 960 FPS
PD FUZES & TSQ SUPERCHARGE MV-1980 FPS
CP FUZE SUPERCHARGE MV 1940 FPS
ELEVATION – MILS
RANGE – YARDS
0
100
200
300
400
500
600
700
800
0
2000
4000
6000
8000
10000
12000
14000

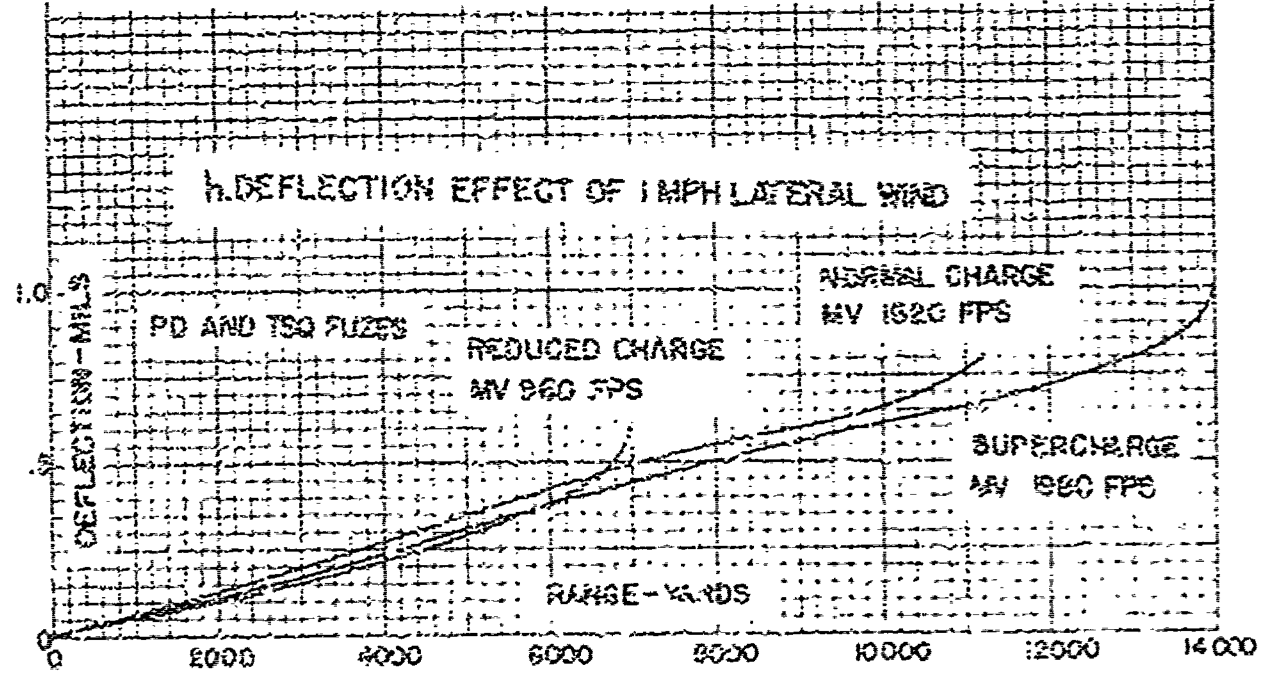
1

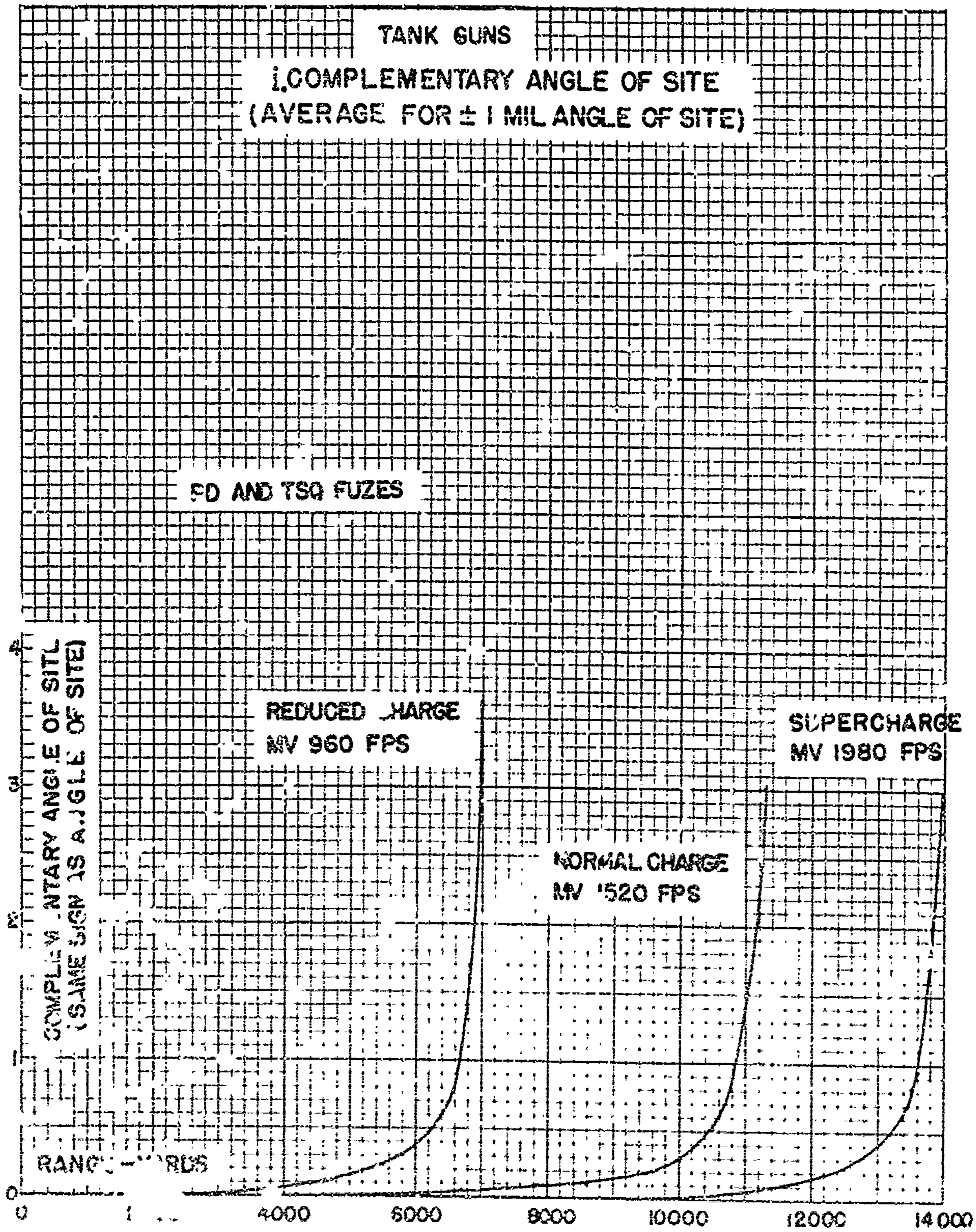

TANK GUNS
ANGLE OF FALL — RANGE CURVES
TSQ AND PD FUZES
NORMAL CHARGE
MV 1520 FPS
REDUCED CHARGE
MV 960 FPS
SUPERCHARGE
MV 1980 FPS
ANGLE OF FALL — MILS
RANGE — YARDS
1200
1000
800
600
400
200
0
0
2000
4000
6000
8000
10000
12000
14000

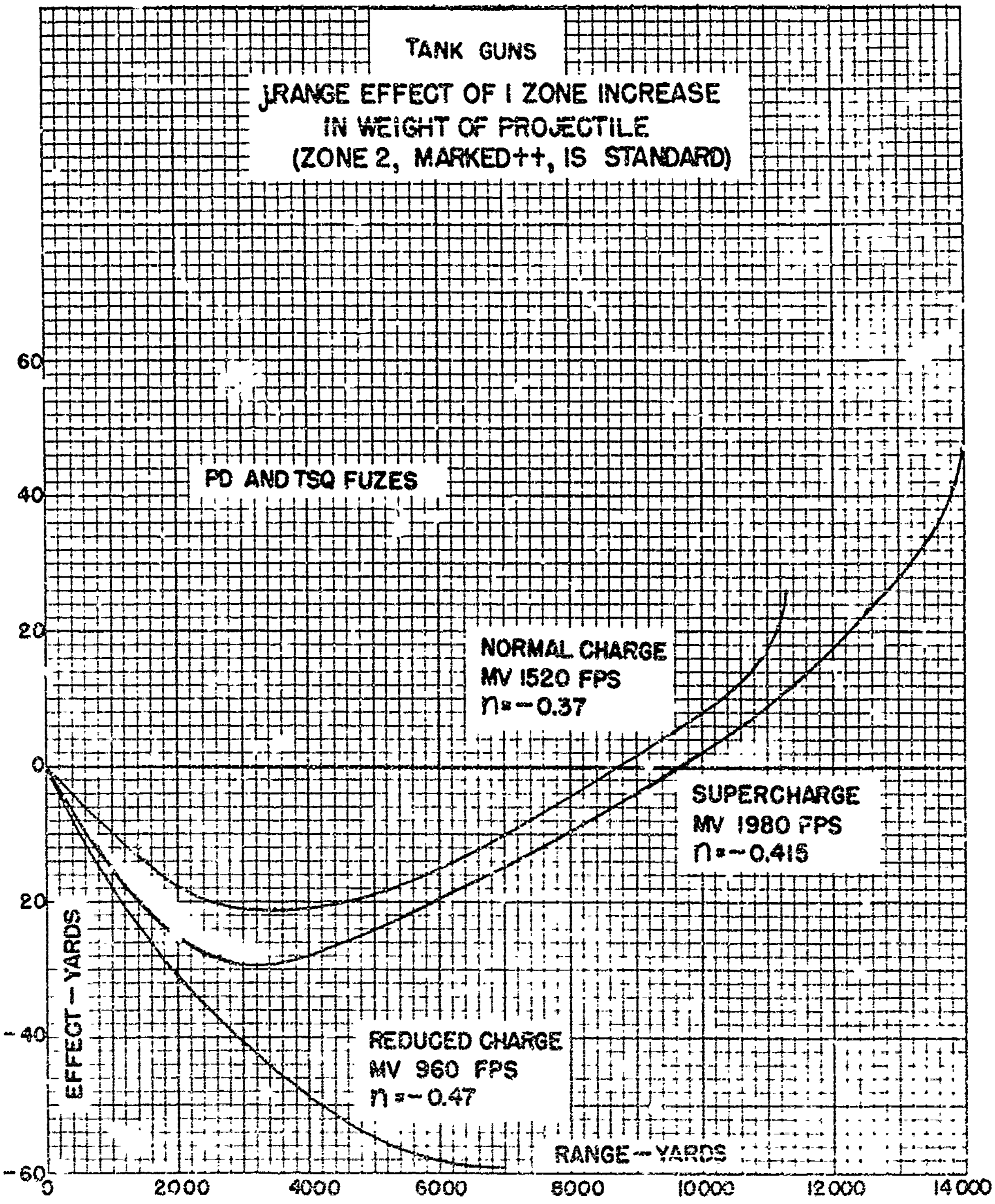

TANK GUNS
e. TERMINAL VELOCITY – RANGE CURVES
PD AND TSQ FUZES
SUPERCHARGE
MV 1980 FPS
NORMAL CHARGE
MV 1520 FPS
REDUCED CHARGE
MV 960 FPS
TERMINAL VELOCITY – FPS
RANGE – YARDS
2000
1800
1600
1400
1200
1000
800
600
0
2000
4000
6000
8000
10000
12000
14000


TANK GUNS
℄ TIME OF FLIGHT – RANGE CURVES
FD AND TSQ FUZES
SUPERCHARGE
MV=1980 FPS
NORMAL CHARGE
MV 1520 FPS
REDUCED CHARGE
MV 960 FPS
TIME OF FLIGHT – SEC
0
10
20
30
40
50
60
RANGE – YARDS
0
2000
4000
6000
8000
10000
12000
14000


TANK GUNS
g. DRIFT-RANGE CURVES
PD AND TSQ FUZES
NORMAL CHARGE
MV 1520 FPS
REDUCED CHARGE
MV 960 FPS
SUPERCHARGE
MV 1980 FPS
DRIFT - MILS
RANGE - YARDS
0
5
10
15
20
0
2000
4000
6000
8000
10000
12000
14000


h. DEFLECTION EFFECT OF 1 MPH LATERAL WIND
PD AND TSQ FUZES
REDUCED CHARGE
MV 960 FPS
NORMAL CHARGE
MV 1520 FPS
SUPERCHARGE
MV 1980 FPS
DEFLECTION-MILS
RANGE-YARDS
0
.5
1.0
0
2000
4000
6000
8000
10000
12000
14000

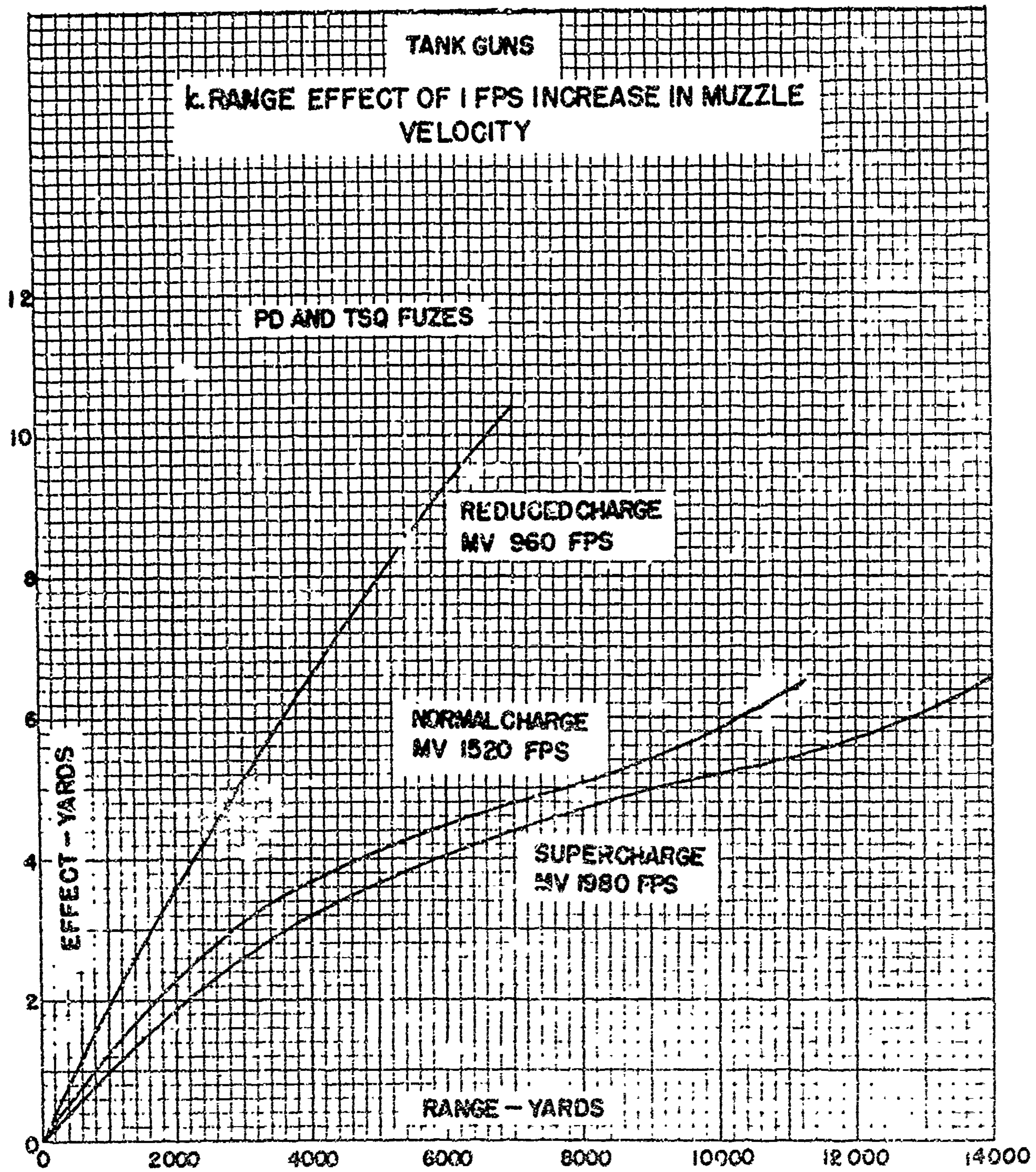

TANK GUNS
i.COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± 1 MIL ANGLE OF SITE)
PD AND TSQ FUZES
REDUCED CHARGE
MV 960 FPS
NORMAL CHARGE
MV 1520 FPS
SUPERCHARGE
MV 1980 FPS
COMPLEMENTARY ANGLE OF SITE
(SAME SIGN AS ANGLE OF SITE)
RANGE—YARDS
0
1
2
3
4
0
4000
6000
8000
10000
12000
14000

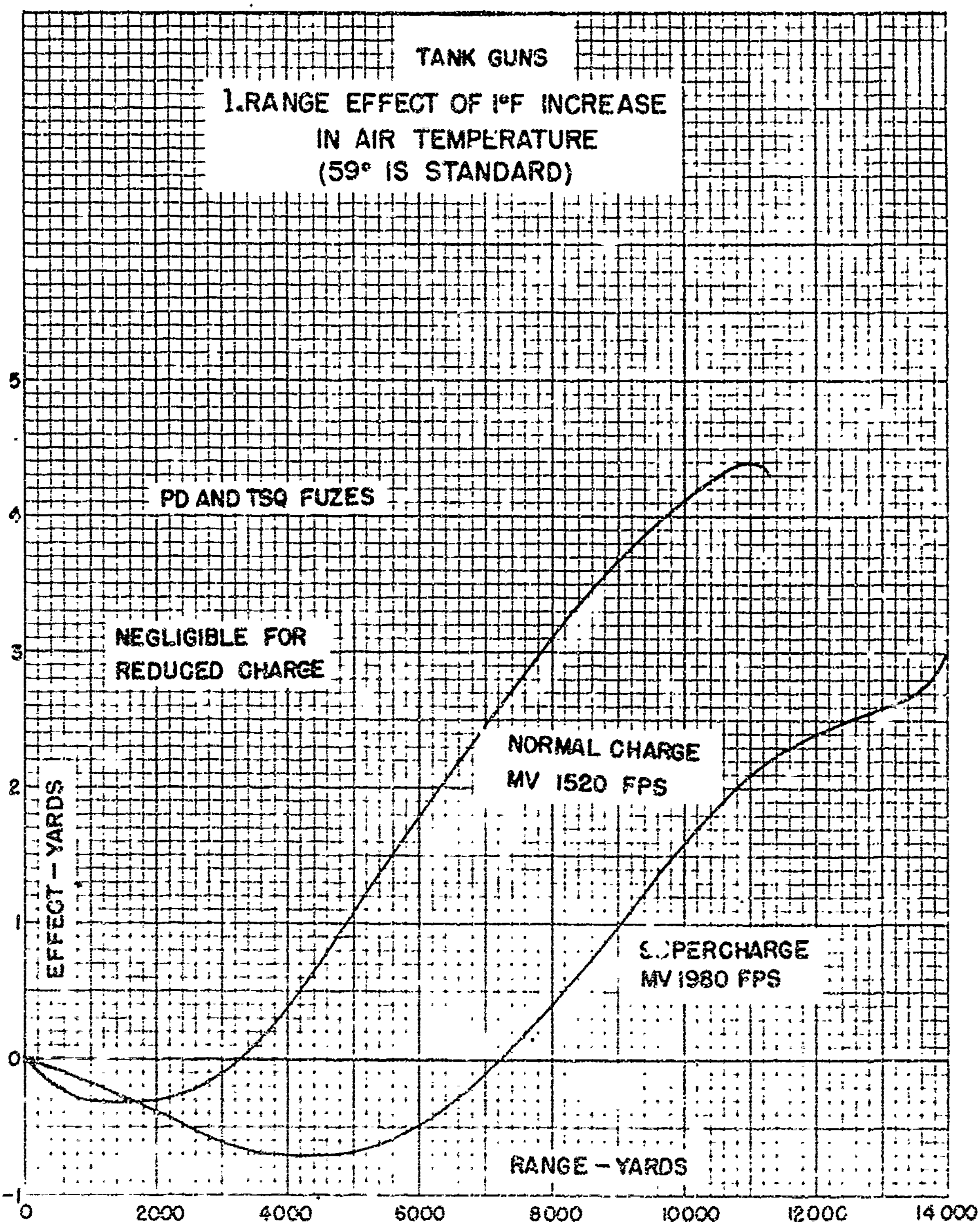


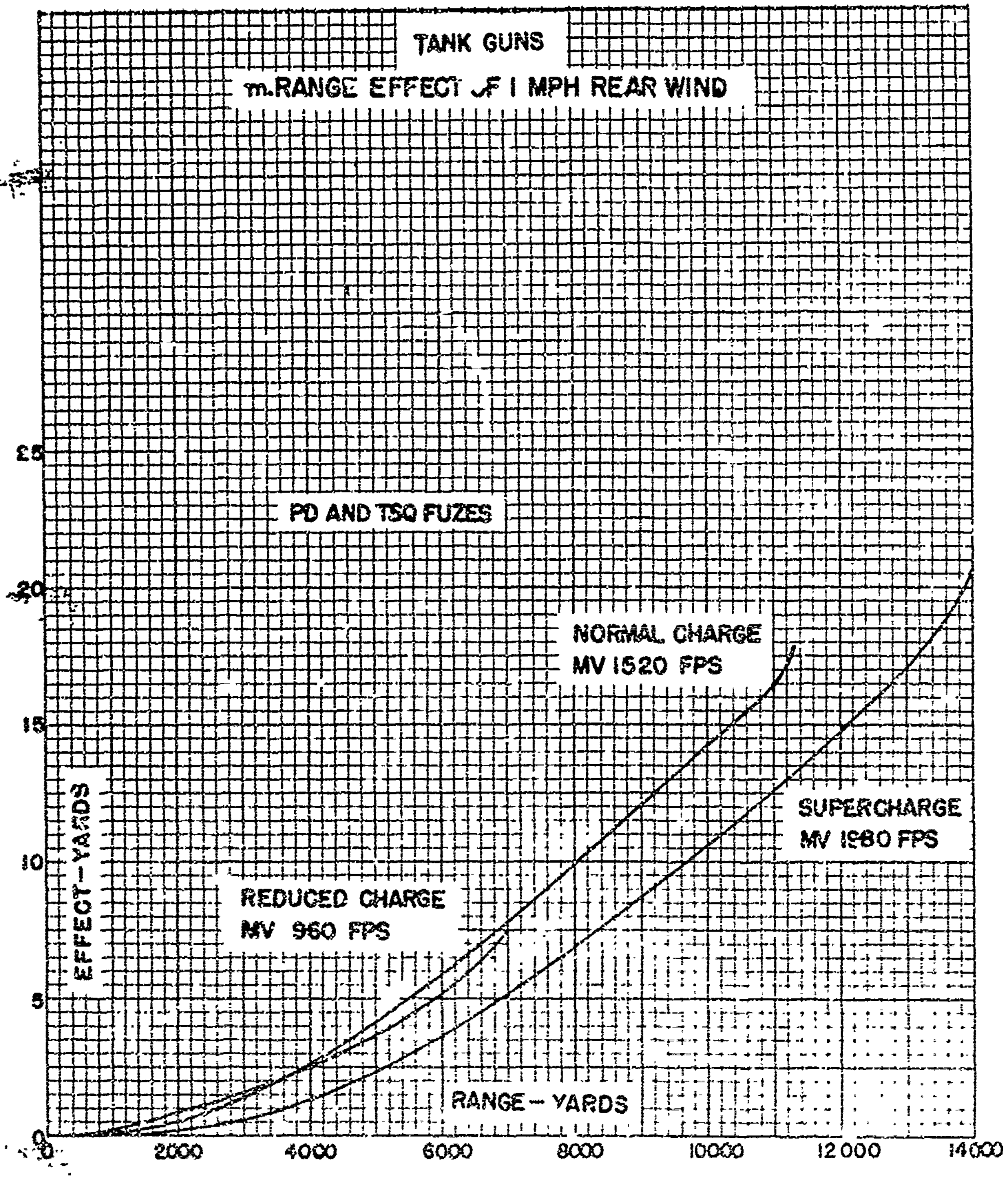
TANK GUNS

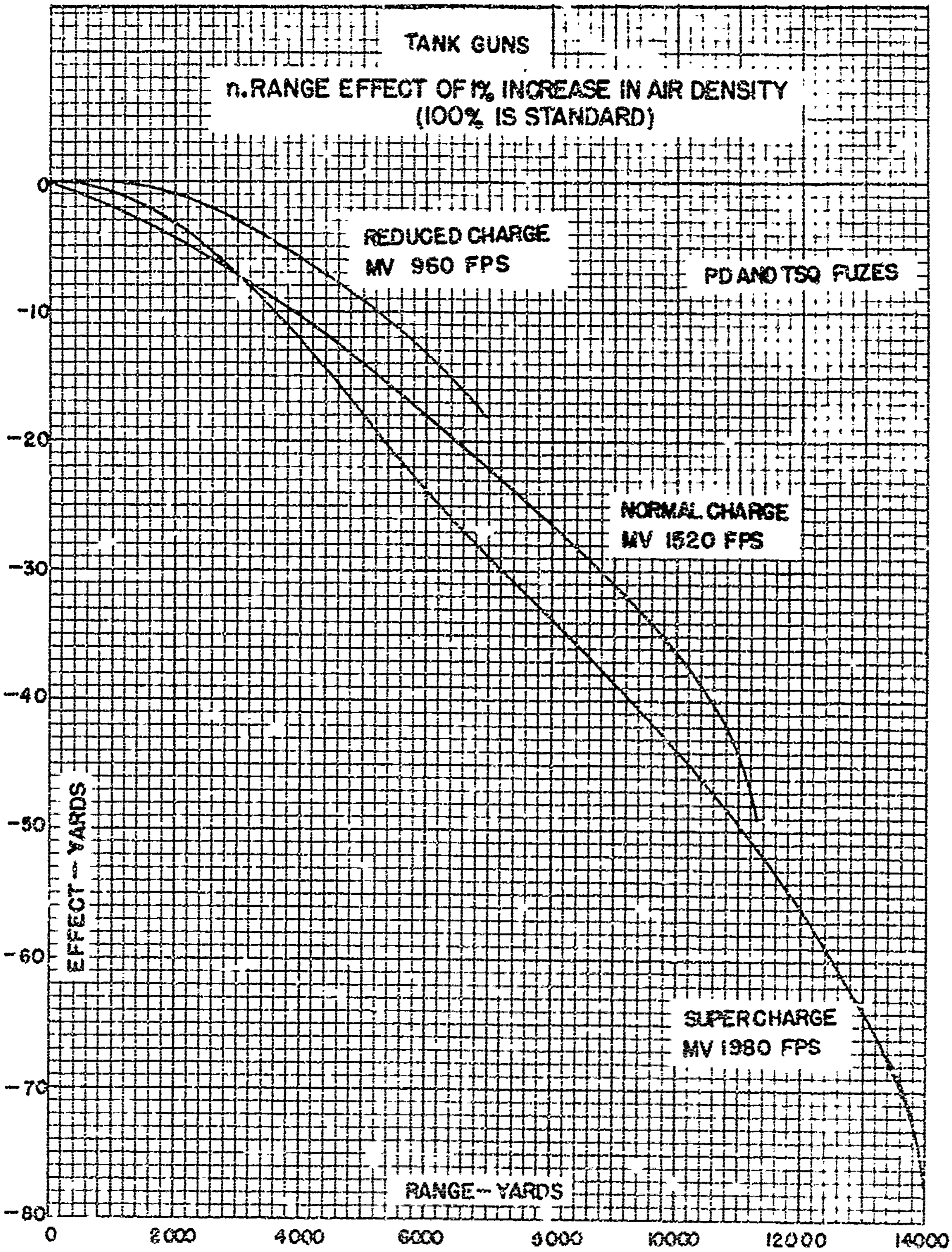
RANGE EFFECT OF 1 ZONE INCREASE IN WEIGHT OF PROJECTILE (ZONE 2, MARKED++, IS STANDARD)

PD AND TSQ FUZES


TANK GUNS
k. RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY
PD AND TSQ FUZES
REDUCED CHARGE
MV 960 FPS
NORMAL CHARGE
MV 1520 FPS
SUPERCHARGE
MV 1980 FPS
EFFECT – YARDS
RANGE – YARDS
0
2
4
6
8
10
12
0
2000
4000
6000
8000
10000
12 000
14000


TANK GUNS
1. RANGE EFFECT OF 1°F INCREASE
IN AIR TEMPERATURE
(59° IS STANDARD)
PD AND TSQ FUZES
NEGLIGIBLE FOR
REDUCED CHARGE
NORMAL CHARGE
MV 1520 FPS
SUPERCHARGE
MV 1980 FPS
EFFECT — YARDS
RANGE — YARDS
5
4
3
2
1
0
-1
0
2000
4000
6000
8000
10000
12000
14 000


TANK GUNS
m.RANGE EFFECT OF 1 MPH REAR WIND
PD AND TSQ FUZES
NORMAL CHARGE
MV 1520 FPS
SUPERCHARGE
MV 1980 FPS
REDUCED CHARGE
MV 960 FPS
EFFECT – YARDS
RANGE – YARDS
0
5
10
15
20
25
0
2000
4000
6000
8000
10000
12 000
14000


TANK GUNS
n. RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
REDUCED CHARGE
MV 960 FPS
PD AND TSQ FUZES
NORMAL CHARGE
MV 1520 FPS
SUPERCHARGE
MV 1980 FPS
EFFECT — YARDS
RANGE — YARDS
0
-10
-20
-30
-40
-50
-60
-70
-80
0
2000
4000
6000
8000
10000
12000
14000

10. Firing table data: Aircraft Guns. FT 75AC-AW-1.

Guns, 75-mm, M5A1 and M10 (mounted in aircraft). MV: 1,950 fps. Twist of rifling: 1/22. Fuze: PD, M57. OCM items 20756 and 20991 recommended and approved the use of the HE Shell M48 in the 75-mm Aircraft Gun M4, which is now obsolete.

a. Aerodynamic constants.

Form factor, i (relative to drag function for HE Shell M48 with PD Fuze M57)	1.00
Ballistic coefficient, C (relative to drag function for HE Shell M48 with PD Fuze M57)	1.686
Normal stability factor, s_s	1.857
Damping constant, c'	0.000, 964, 1 ft^{-1}
Damping constant, c"	0.000, 026, 6 ft^{-1}
Windage jump coefficient, b	24,931 mils. fps
Yaw-drag coefficient, $K_{D\delta}$	16.4 rad^{-2}

b. Trajectory data. The firing tables apply to a gun flexibly mounted in elevation on an airplane flying horizontally, or mounted at a fixed elevation on a diving airplane, and firing at a target on the ground. They list the following data and certain effects on them for true air speeds of 250 and 350 mph:

Time of flight.

Horizontal-angle between the gun and the line of sight.

Vertical angle between the gun and the line of sight.

SECTION V

EFFECT DATA

	Paragraph
Ricochet data	11
Effectiveness	12
Fragmentation	13
Penetration	14

11. **Ricochet data.** The following data on ricochet of 75-mm HE Shell M48 with PD Fuzes M48A2 and M51A4 were taken from volume III of "Terminal Ballistic Data".

a. HOWITZER, 75-MM, M1A1, M2 and M3

TABLE 73
TANK GUNS, 75-mm, M3, M6 and M17

	Range	Angle of Fall	Angle of Recovery	Impact to Burst	Height of Burst	PE in Height of Burst
	yd	mils	mils	yd	ft	ft
Charge 1 MV 700 fps	1,000	109	155	26	12	2
	2,000	242	265	17	14	3
	3,000	415	315	7	7	2
Charge 2 MV 810 fps	1,000	82	120	32	12	2
	2,000	178	220	24	16	3
	3,000	295	295	15	14	3
Charge 3 MV 950 fps	1,000	58	90	40	11	2
	2,000	127	175	33	21	4
	3,000	208	245	25	18	4
	4,000	305	295	17	15	4
	5,000	425	315	8	8	3
Charge 4 MV 1,250 fps	1,000	38	60	51	11	2
	2,000	86	125	42	16	3
	3,000	142	180	35	20	4
	4,000	206	245	28	21	4
	5,000	279	285	21	18	4
	6,000	363	310	14	14	4

b. TANK GUNS, 75-MM, M3, M6 and M17

TABLE 74
TANK GUNS, 75-MM, M3, M6 and M17

	Range	Angle of Fall	Angle of Recovery	Impact to Burst	Height of Burst	PE in Height of Burst
	yd	mils	mils	yd	ft	ft
Reduced Charge MV 950 fps	1,000	59	90	40	11	2
	2,000	126	170	33	17	3
	3,000	206	245	25	18	4
	4,000	301	295	17	18	4
Normal Charge MV 1,500 fps	1,000	28	45	62	8	2
	2,000	65	100	50	15	3
	3,000	115	160	41	19	4
	4,000	174	220	33	22	5
	5,000	240	265	26	21	5
	6,000	313	300	19	17	4
	7,000	394	315	13	12	4
Super Charge MV 1,950 fps	1,000	13	25	28	2	0
	2,000	36	60	23	4	1
	3,000	70	105	19	6	1
	4,000	116	160	14	7	1
	5,000	171	315	12	6	2
	6,000	234	260	9	7	2
	7,000	303	295	7	6	2
	8,000	378	315	5	4	1

12. Effectiveness. The following data on effectiveness of HE Shell M48 with PD Fuze M54 were taken from volume III of "Terminal Ballistic Data".

a. NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 50% EFFECT FOR 10,000 SQ YD IN AREA FIRE

HOWITZER, 75-mm, M1A1, M2 and M3.
Charge 4: MV 1250 fps

Range yd	Type of Fire		
	Impact	Time	Time and Impact
2,000	210	230	170
5,000	680	700	500

b. NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 90% PROBABILITY OF AT LEAST ONE EFFECTIVE HIT IN AIMED FIRE

(1) **Howitzer, 75-mm, M1A1, M2 and M3.**
Charge 4: MV 1250 fps

Range yd	Type of Fire		
	Impact	Time	Time and Impact
2,000	24	340	43
5,000	460	1400	560

(2) **Tank Gun, 75-mm, M3, M6 and M17.**
Supercharge: MV 1950 fps

Range yd	Type of Fire		
	Impact	Time	Time and Impact
2,000	7	340	15
5,000	120	780	180

13. Fragmentation.

a. Sand pit test. The sand pit and panel tests of HE Shell M46 with PD Fuze M39 were reported in Ballistic Research Laboratory Report No. 126, "Fragmentation of the 75-mm HE Shell T3 as determined by panel and pit fragmentation tests". The weight of the PD Fuze M39 is 2.35 lb and its contour is slightly different from that of the PD Fuze M48A2.

(1) Four projectiles were placed in boxes and detonated in the sand pit. The fragments were then separated from the sand with a hand screen made of 0.03-inch wire with 4 meshes per inch. Finally, they were grouped according to size by being sifted thru four screens with the following average dimensions:

Screen No.	Meshes per inch	Diam of wire, inch	Size of Opening	
			Side, inch	Area, Sq in.
1	1	.16	.84	.71
2	2	.14	.36	.12
3	3	.10	.23	.053
4	4	.08	.17	.029

(2) The average weight of the shell and fuze, without the TNT, was 13.29 lb. The following table shows the average number and weight of the fragments in each group:

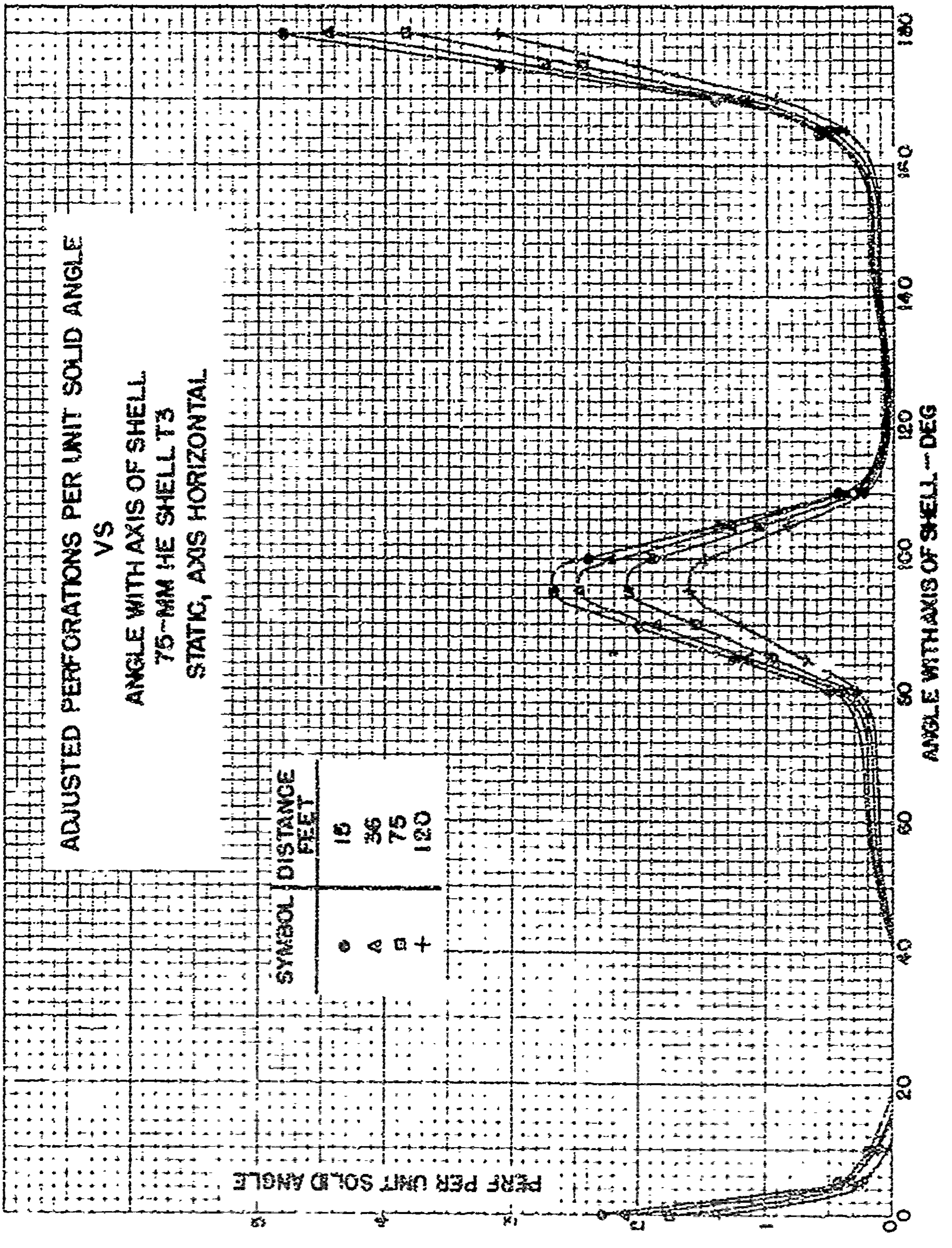
Fragments caught by following screens: (Avg of 4 rounds)	No. of Fragments	% of total No. of Fragments	Weight of Fragments lb	% of empty Shell and Fuze
Screen No. 1	6	0.8	2.043	15.4
Screen No. 2	272	34.9	8.449	63.6
Screen No. 3	255	32.7	1.713	12.9
Screen No. 4	142	18.2	0.384	2.7
Thru Screen No. 4	104	13.4	0.139	1.0
	779	100.0	12.708	95.6

b. **Panel test.**

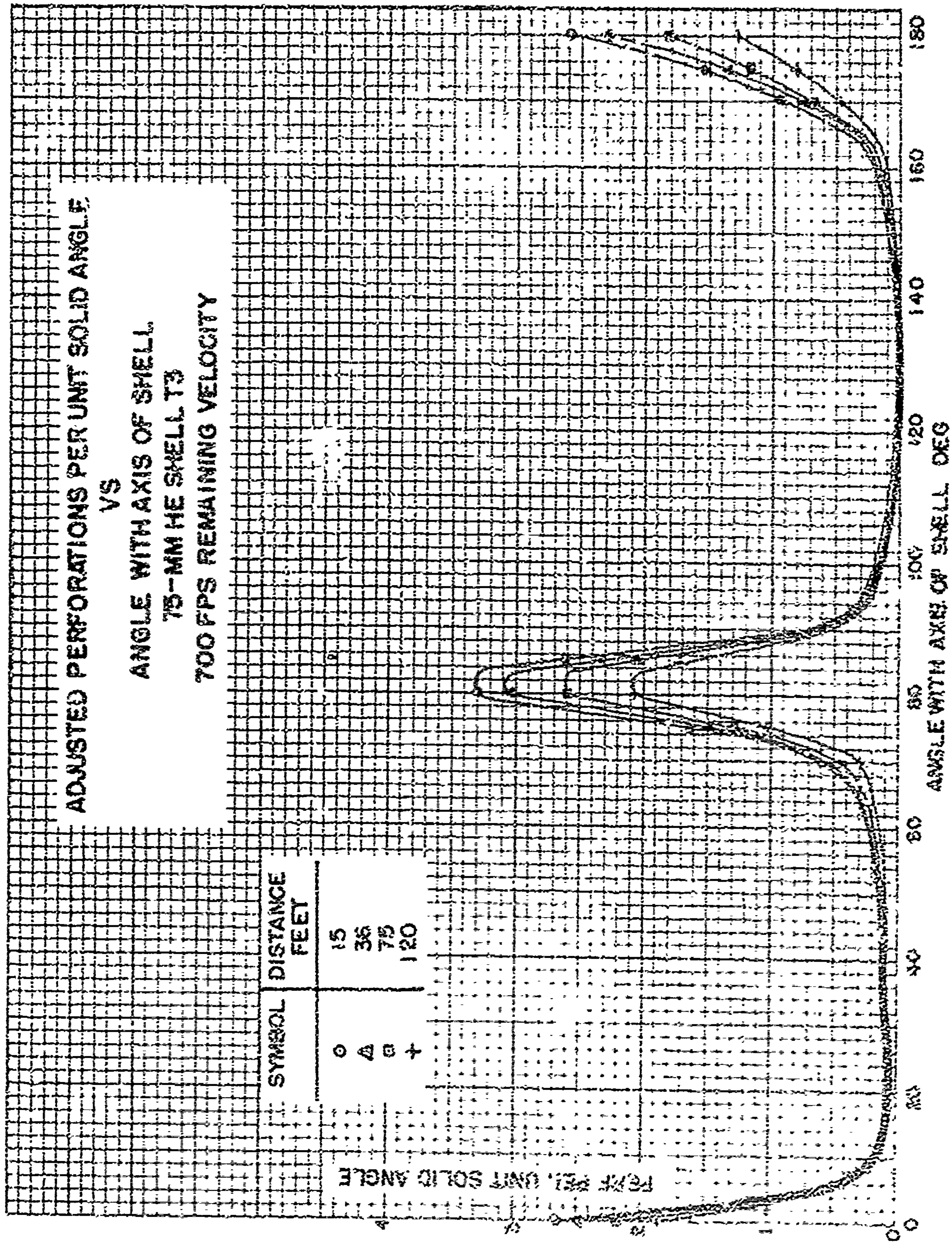
(1) Four panels were made of spruce boards with a nominal thickness of 1 inch. Panel A was semicircular, with a radius of 15 feet, and 9 feet high: it was placed on the left side of the line of fire, and the shell was detonated at the center of the arc, about midway between the top and bottom of the panel. For the same rounds, panel B was placed on the right side of the line of fire, with the same center: it was semicircular, with a radius of 36 feet, and 9 feet high. Panel C was semicircular, with a radius of 75 feet, and 12 feet high: it was located like panel A, but on different rounds. Panel D extended for about 45° at a radius of 120 feet, and was 12 feet high: it was placed opposite panel C, in such a position as to include the sidespray at remaining velocities up to 1100 fps. The data given below were obtained from 5 rounds fired statically in a horizontal position, 5 rounds with a remaining velocity of 700 fps when burst, and 5 rounds with a remaining velocity of 1085 fps, with each pair of panels.

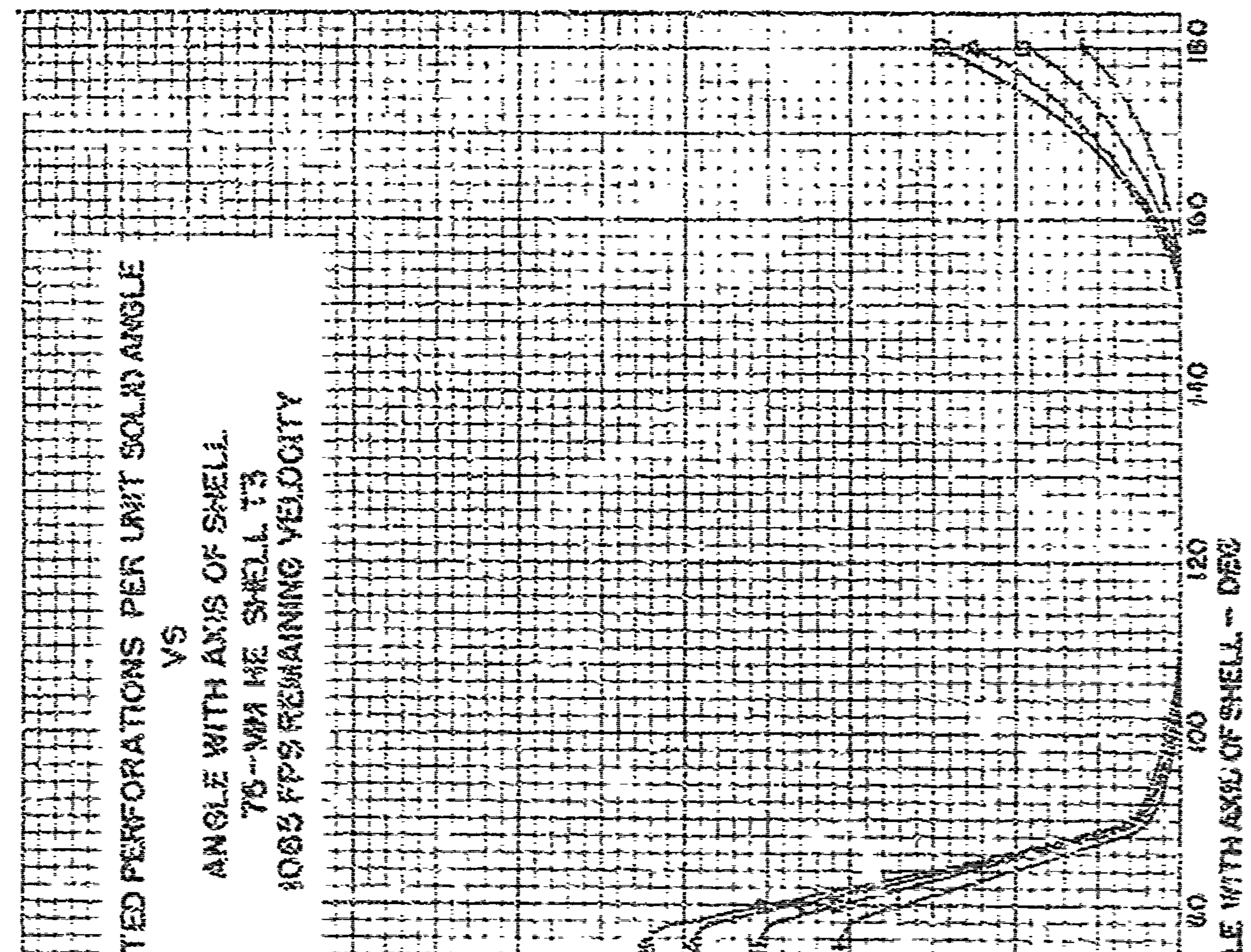
(2) BRL Report 126 defines certain terms as follows; A perforating fragment is one that travels completely thru the panel. A penetrating fragment is one that goes at least 1/16 inch into the panel, but does not go all the way thru. A unit solid angle is 1/100 of the solid angle subtended by a unit of spherical surface at unit radius. Polar angles are measured with respect to a horizontal coordinate system with its origin at the center of the panels, at an elevation midway between the top and bottom of the panels. It is assumed that the center of gravity of the projectile coincides with the origin of coordinates, that the axis of the shell is horizontal, and that the polar axis lies along the extension of the shell axis in the direction of the nose.

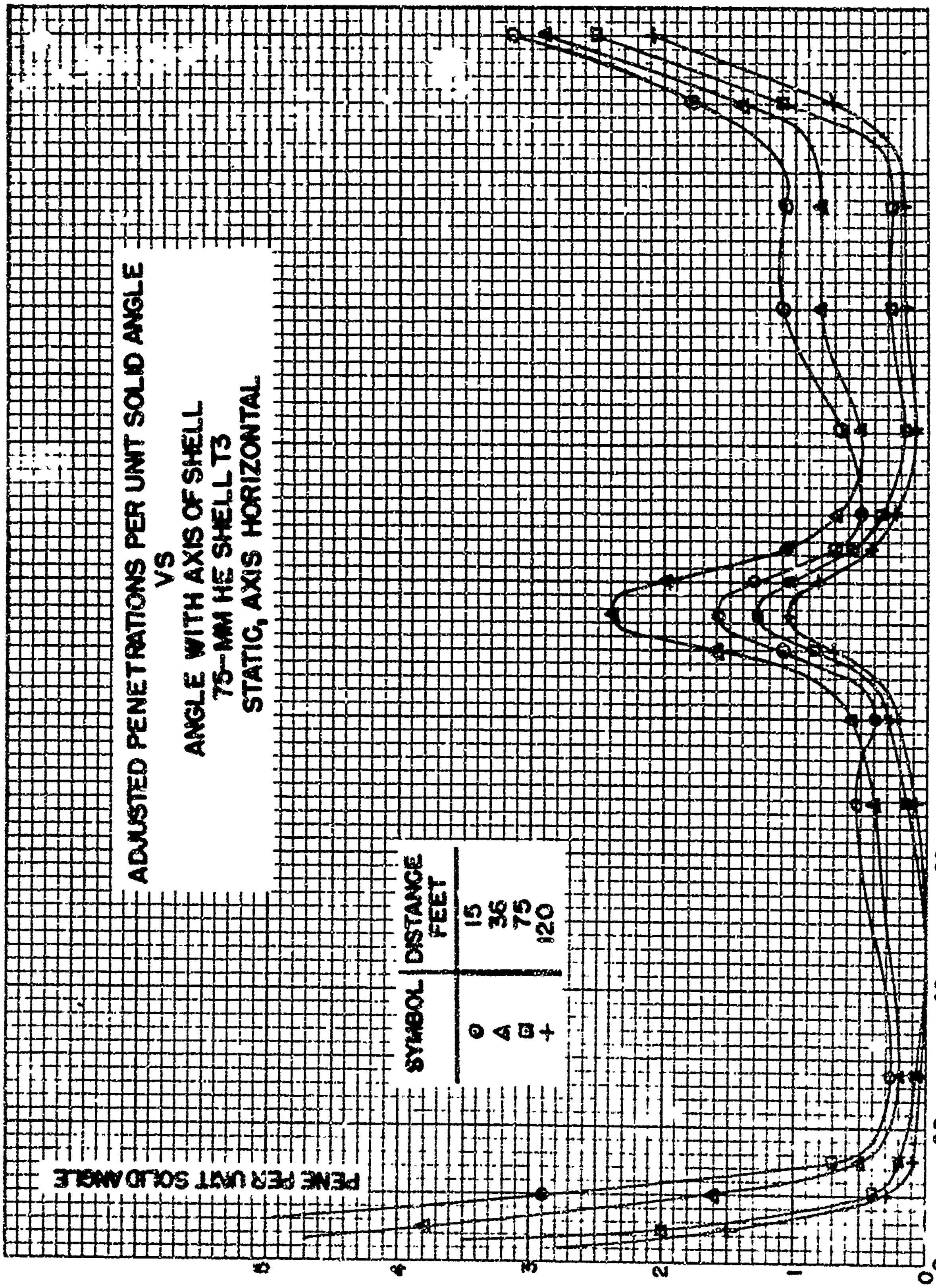
(3) The results of the panel test are shown by the following fragmentation density - polar angle curves.



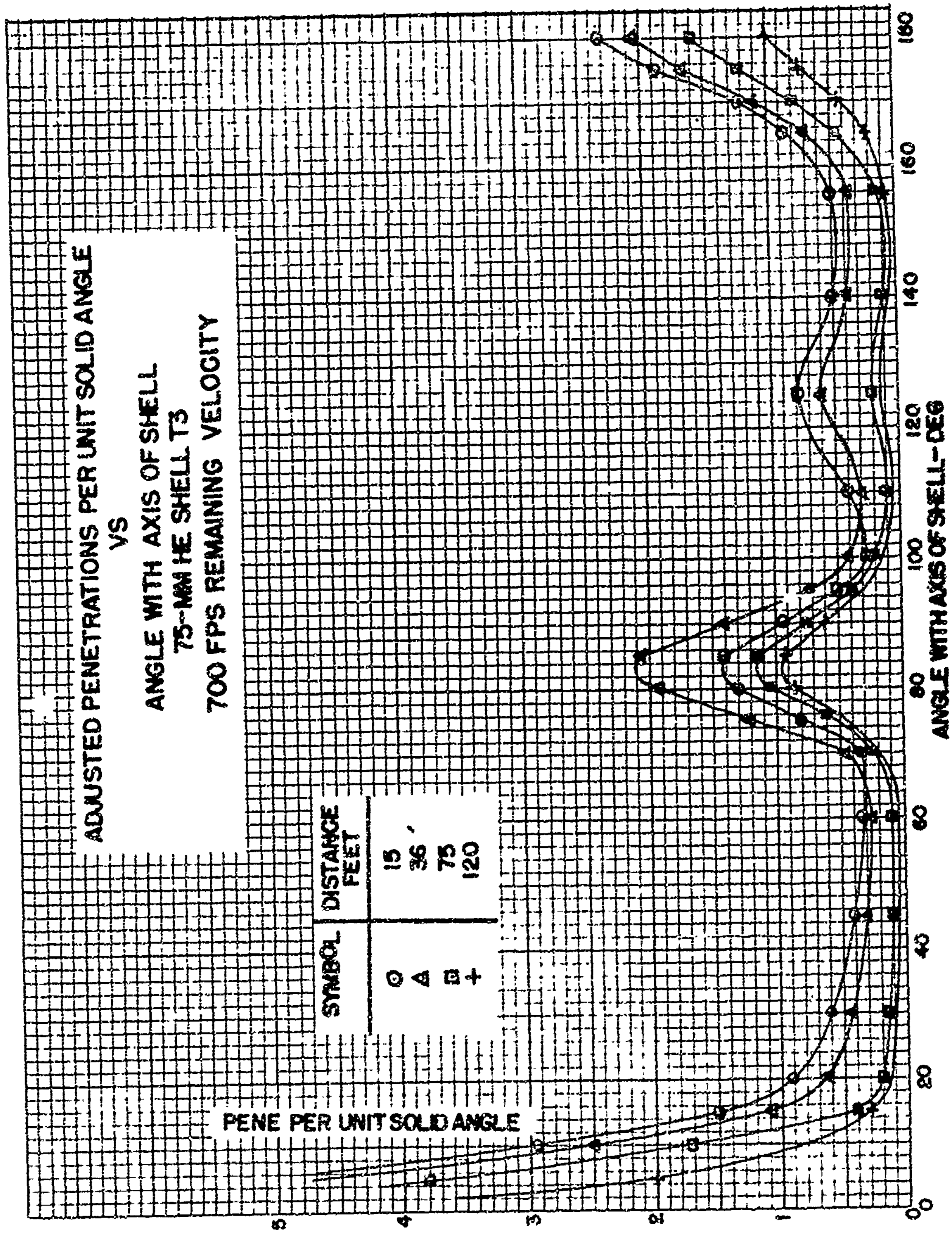
ADJUSTED PERFORATIONS PER UNIT SOLID ANGLE
VS
ANGLE WITH AXIS OF SHELL
75-MM HE SHELL T3
STATIC, AXIS HORIZONTAL


ADJUSTED PERFORATIONS PER UNIT SOLID ANGLE
VS
ANGLE WITH AXIS OF SHELL
75-MM HE SHELL T3
700 FPS REMAINING VELOCITY
SYMBOL
DISTANCE FEET
○ 15
△ 36
□ 75
+ 120
PERF PER UNIT SOLID ANGLE
ANGLE WITH AXIS OF SHELL DEG
0
1
2
3
4
0
20
40
60
80
100
120
140
160
180


ADJUSTED PERFORATIONS PER UNIT SOLID ANGLE
VS
ANGLE WITH AXIS OF SHELL
75-MM HE SHELL T3
1085 FPS REMAINING VELOCITY
SYMBOL
DISTANCE FEET
15
36
75
120
PERF PER UNIT SOLID ANGLE
0
1
2
3
4
5
ANGLE WITH AXIS OF SHELL - DEG
0
20
40
60
80
100
120
140
160
180

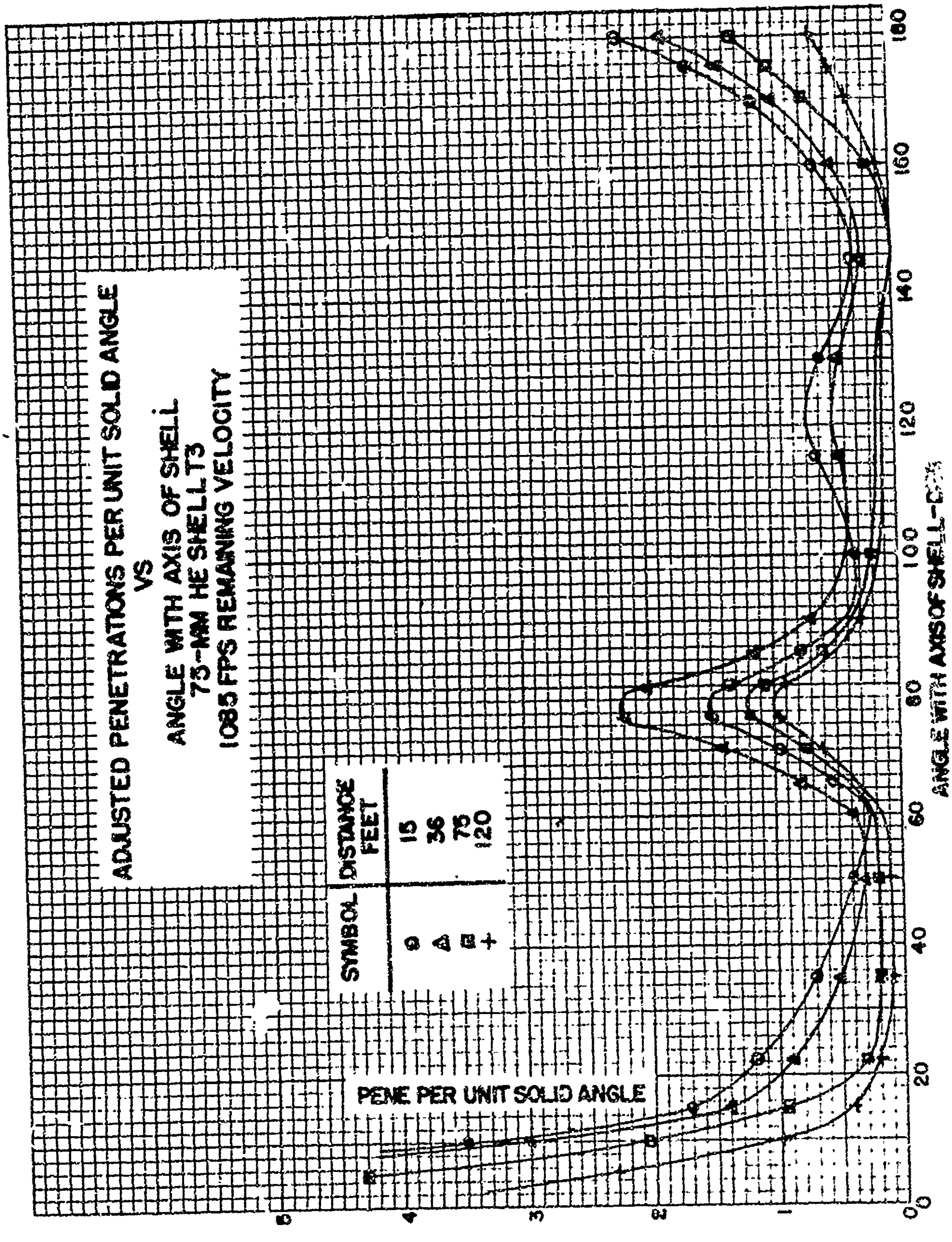


ADJUSTED PENETRATIONS PER UNIT SOLID ANGLE
VS
ANGLE WITH AXIS OF SHELL
75-MM HE SHELL T3
STATIC, AXIS HORIZONTAL



ADJUSTED PENETRATIONS PER UNIT SOLID ANGLE
VS
ANGLE WITH AXIS OF SHELL
75-MM HE SHELL T5
700 FPS REMAINING VELOCITY

SYMBOL	DISTANCE FEET
⊙	15
△	36
⊡	75
+	120

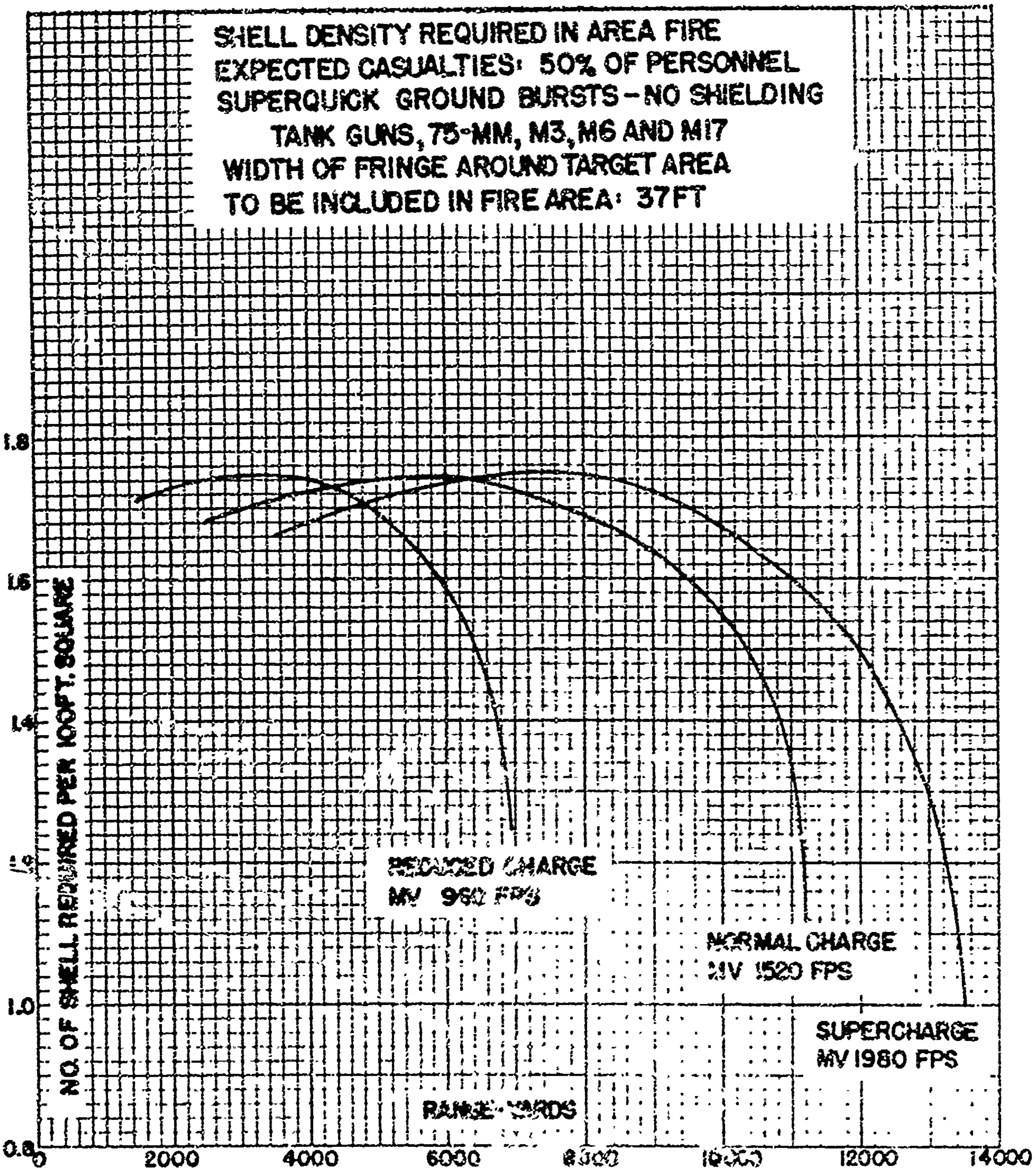

ADJUSTED PENETRATIONS PER UNIT SOLID ANGLE
VS
ANGLE WITH AXIS OF SHELL
75-MM HE SHELL T3
1085 FPS REMAINING VELOCITY
SYMBOL
DISTANCE FEET
⊙ 15
△ 36
⊡ 75
+ 120
PENE PER UNIT SOLID ANGLE
0
1
2
3
4
5
0
20
40
60
80
100
120
140
160
180
ANGLE WITH AXIS OF SHELL–DEG

c. **Casualties.** All the following data on fragmentation of HE Shell M48 with PD and TSQ Fuzes were taken from volume III of "Terminal Ballistic Data" and TM 9-1907, "Ballistic Data, Performance of Ammunition". The initial fragment velocity of this shell is 3,120 fps.

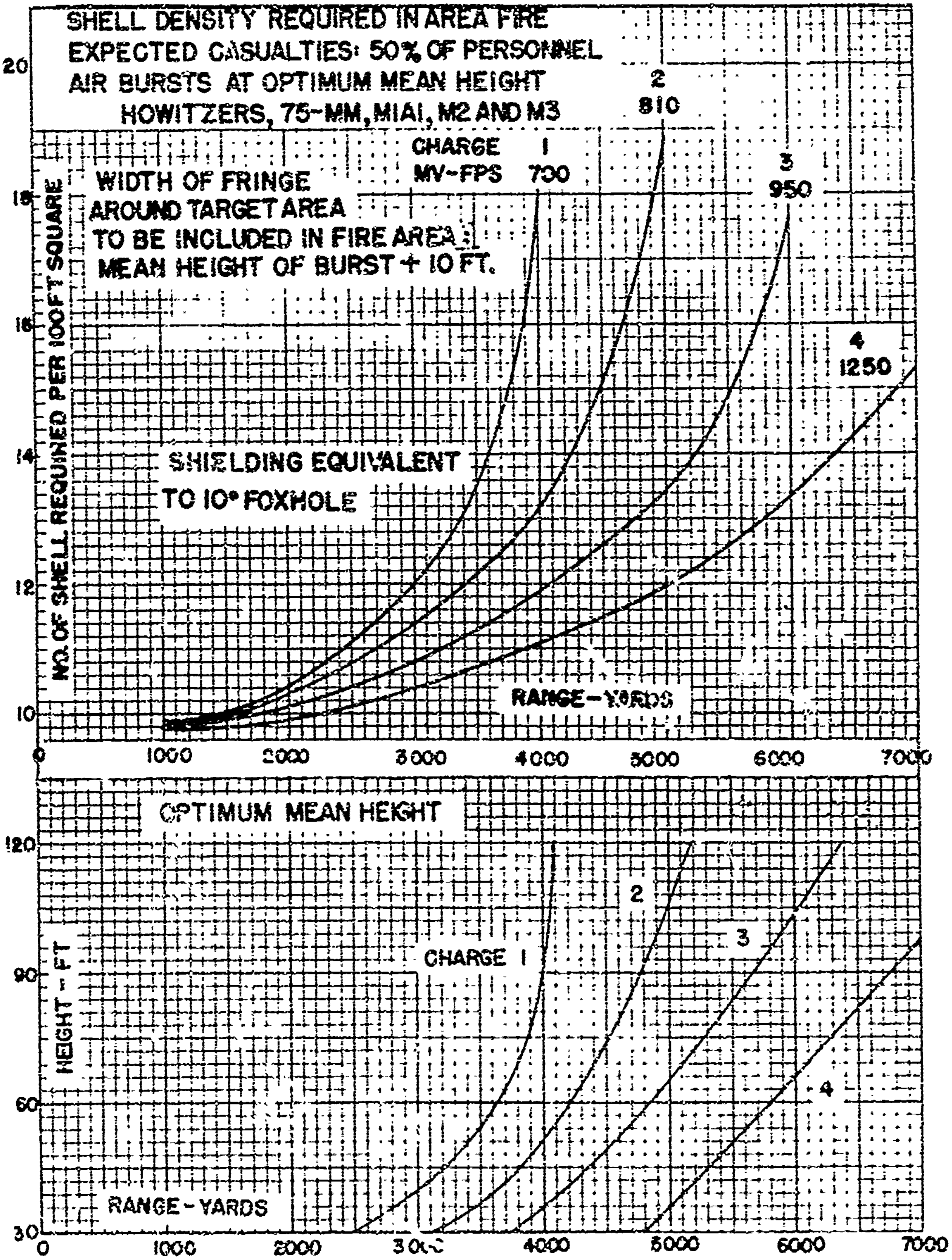
TABLE 38

CASUALTIES

Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (fps)
r	N	B	m	v
20	1070	0.213	0.014	2060
30	920	0.0809	0.018	1820
40	750	0.0375	0.024	1570
60	640	0.0141	0.037	1270
80	510	0.0084	0.051	1080
100	450	0.0036	0.063	972
150	370	0.0013	0.090	813
200	320	0.0006	0.116	716
300	250	0.0002	0.173	587
400	200	0.0001	0.244	494

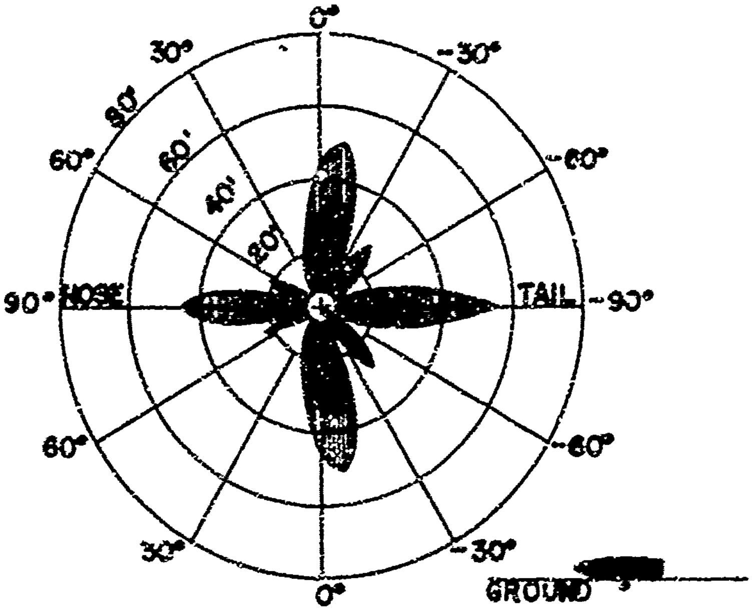


SHELL DENSITY REQUIRED IN AREA FIRE
EXPECTED CASUALTIES: 50% OF PERSONNEL
SUPERQUICK GROUND BURSTS – NO SHIELDING
TANK GUNS, 75-MM, M3, M6 AND M17
WIDTH OF FRINGE AROUND TARGET AREA
TO BE INCLUDED IN FIRE AREA: 37 FT

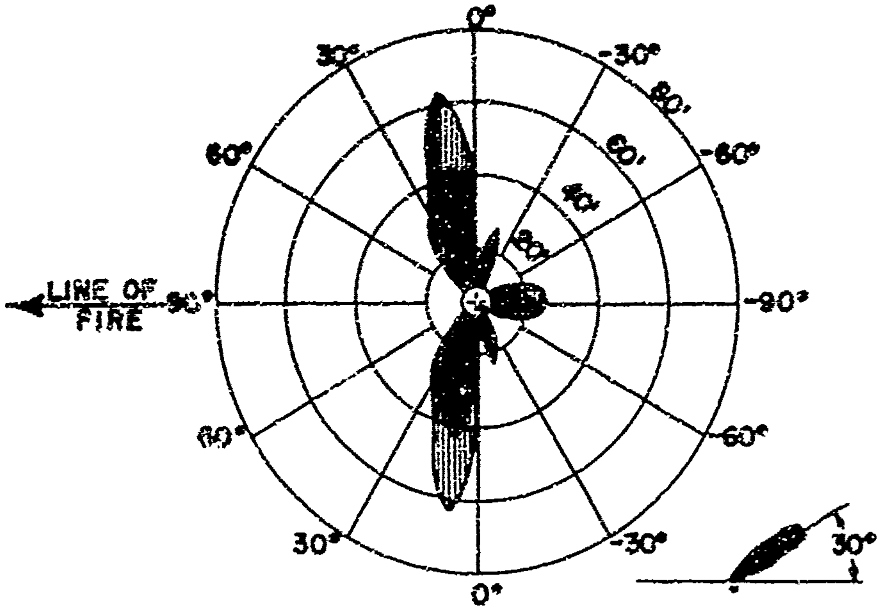

SHELL DENSITY REQUIRED IN AREA FIRE
EXPECTED CASUALTIES: 50% OF PERSONNEL
AIR BURSTS AT OPTIMUM MEAN HEIGHT
HOWITZERS, 75-MM, M1A1, M2 AND M3
CHARGE
MV-FPS
1
700
2
810
3
950
4
1250
WIDTH OF FRINGE AROUND TARGET AREA TO BE INCLUDED IN FIRE AREA: MEAN HEIGHT OF BURST + 10 FT.
SHIELDING EQUIVALENT TO 10" FOXHOLE
NO. OF SHELL REQUIRED PER 100 FT SQUARE
RANGE-YARDS
10
12
14
16
18
20
0
1000
2000
3000
4000
5000
6000
7000
OPTIMUM MEAN HEIGHT
CHARGE 1
2
3
4
HEIGHT - FT
RANGE-YARDS
30
60
90
120
0
1000
2000
3000
4000
5000
6000
7000

CASUALTIES

TANK GUNS



INCLINATION 0°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 0 FPS



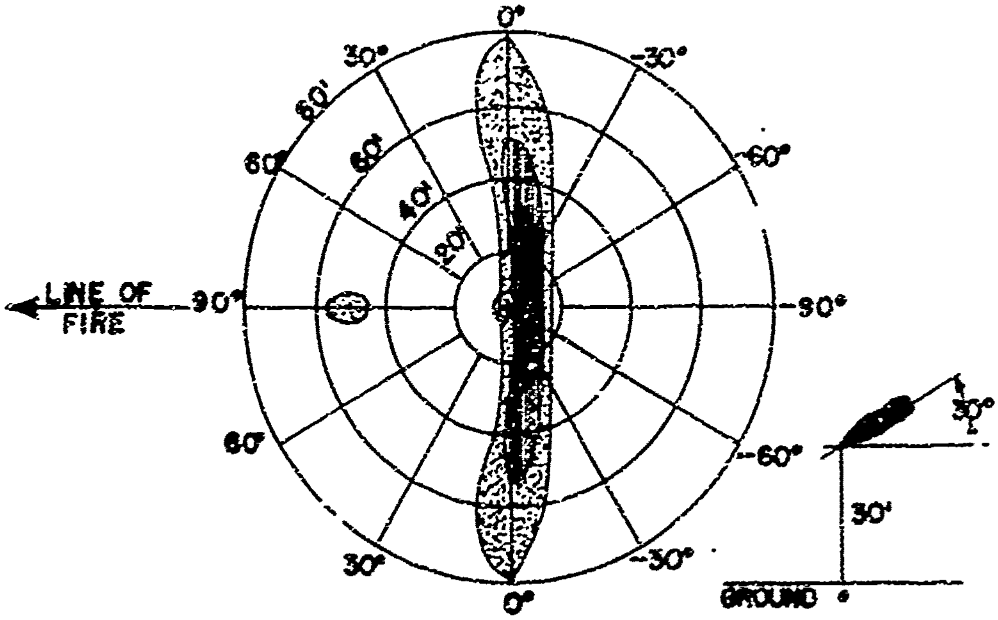
▨ **AT LEAST 1 HIT PER 10 SQ FT**

▩ **AT LEAST 1 HIT PER 4 SQ FT**

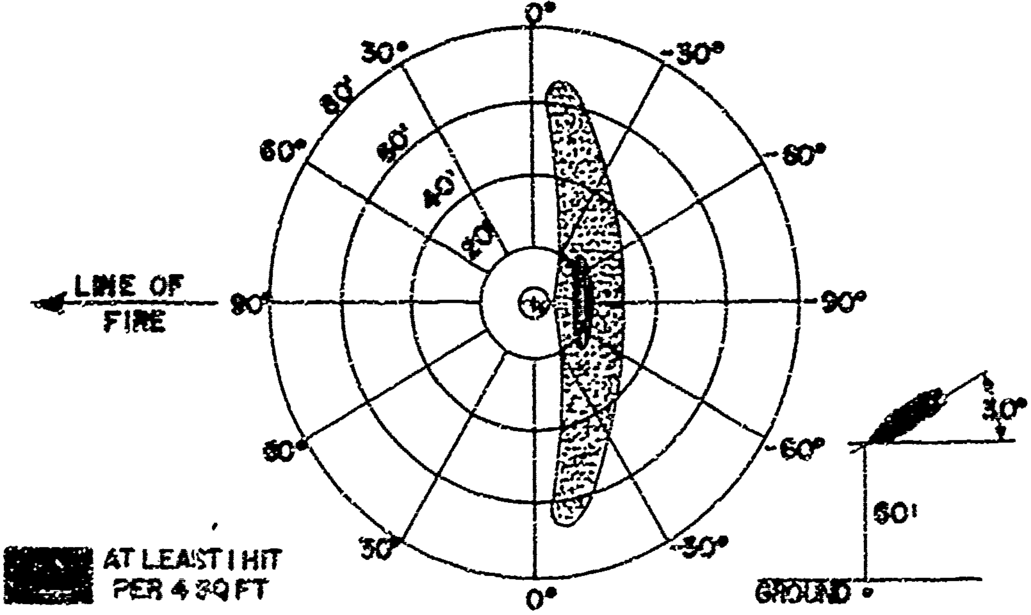
INCLINATION 30°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 800 FPS

CASUALTIES

TANK GUNS



INCLINATION 30°
HEIGHT OF BURST 30 FT
REMAINING VELOCITY 800 FPS



INCLINATION 30°
HEIGHT OF BURST 60 FT
REMAINING VELOCITY 800 FPS

■ AT LEAST 1 HIT PER 4 SQ FT

▥ AT LEAST 1 HIT PER 10 SQ FT

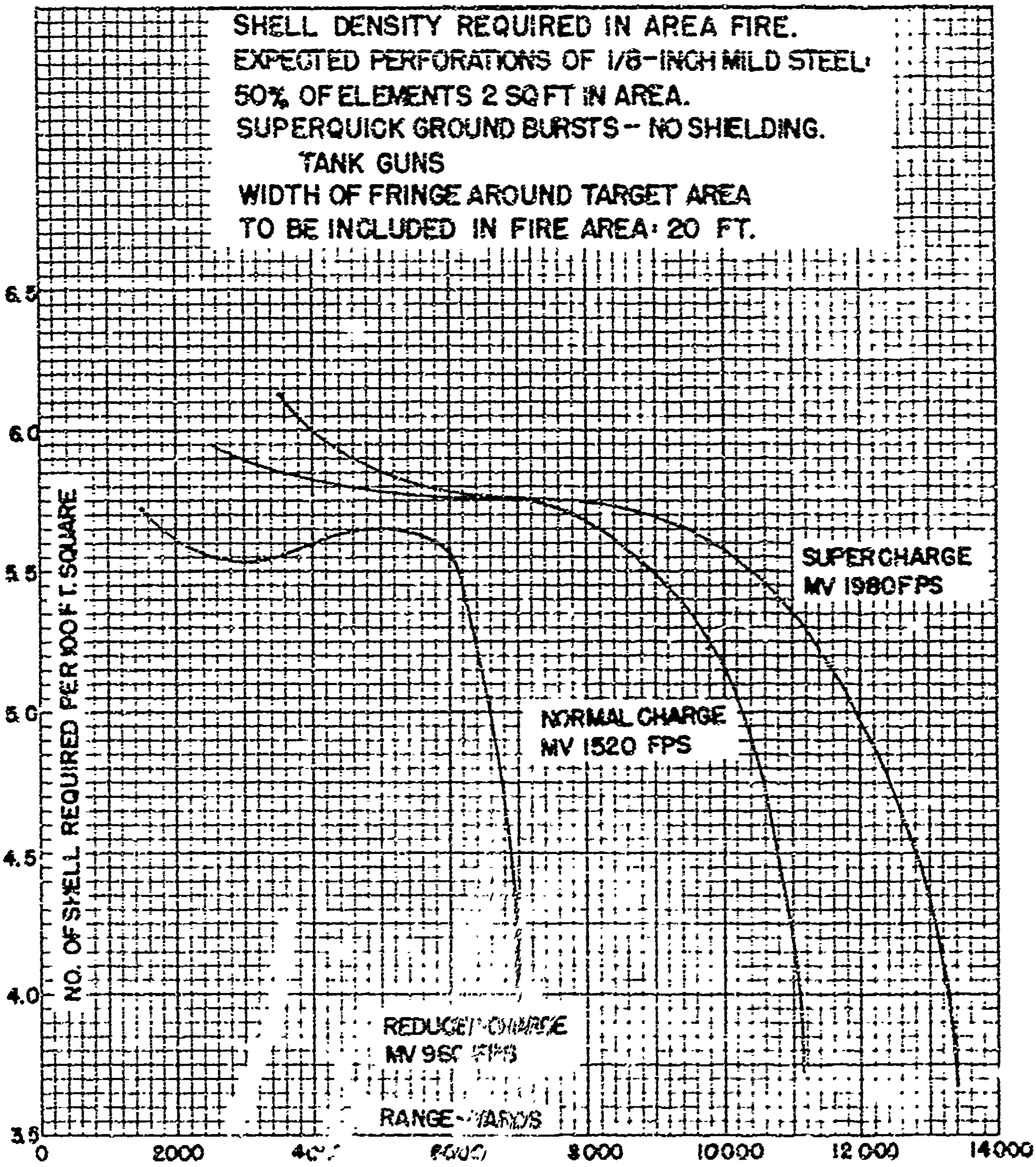
▨ AT LEAST 1 HIT PER 25 SQ FT

d. Perforation of 1/8-inch Mild Steel.

TABLE 39

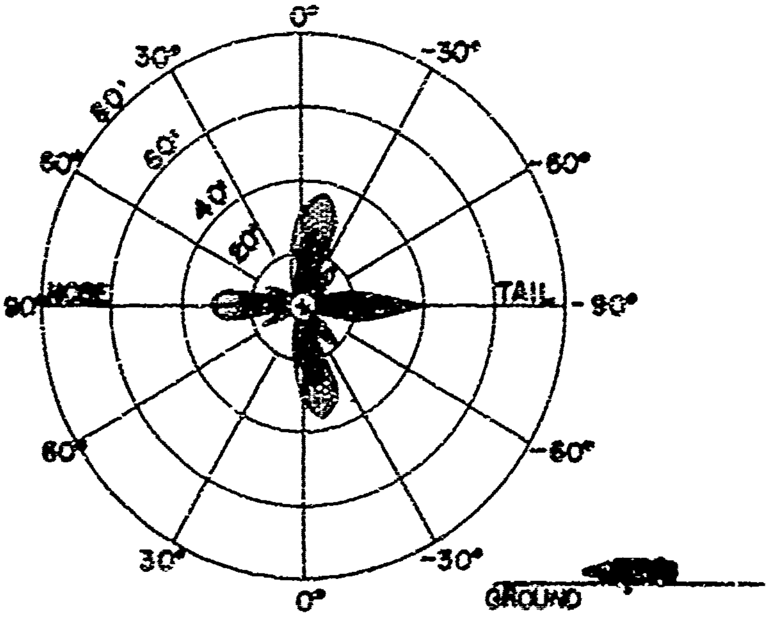
PERFORATION OF 1/8 IN. MILD STEEL

Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (fps)
r	N	B	m	v
20	534	0.108	0.049	2380
30	442	0.0391	0.065	2180
40	385	0.0192	0.082	2010
60	300	0.0066	0.127	1790
80	242	0.0030	0.185	1580
100	197	0.0016	0.253	1430
130	132	0.0006	0.375	1270
160	86	0.0003	0.508	1160
190	57	0.0001	0.655	1080
225	39	0.0001	0.820	1020

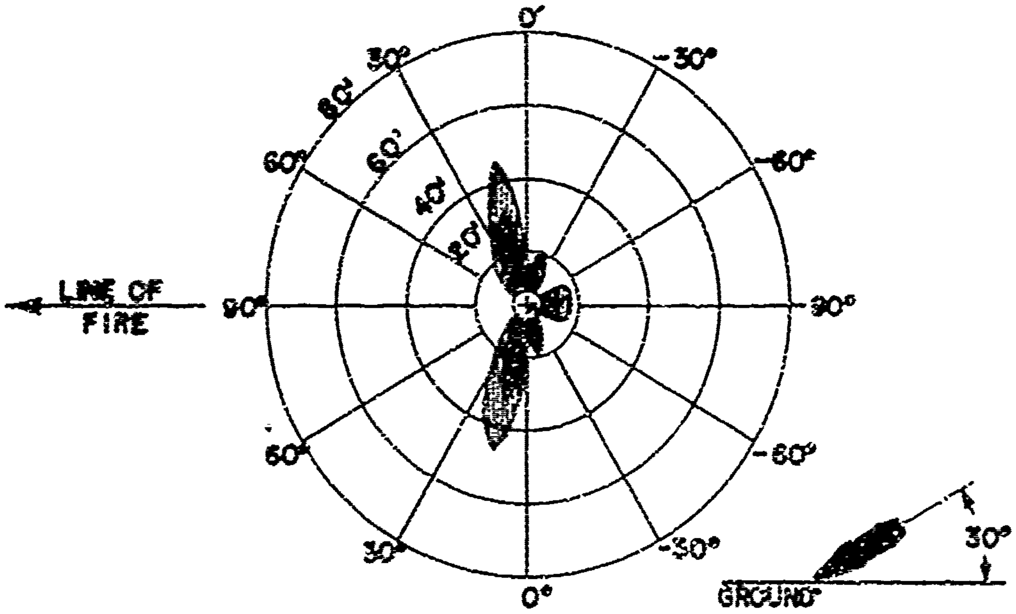

SHELL DENSITY REQUIRED IN AREA FIRE.
EXPECTED PERFORATIONS OF 1/8-INCH MILD STEEL:
50% OF ELEMENTS 2 SQ FT IN AREA.
SUPERQUICK GROUND BURSTS – NO SHIELDING.
TANK GUNS
WIDTH OF FRINGE AROUND TARGET AREA
TO BE INCLUDED IN FIRE AREA: 20 FT.
SUPERCHARGE
MV 1980 FPS
NORMAL CHARGE
MV 1520 FPS
REDUCED CHARGE
MV 960 FPS
NO. OF SHELL REQUIRED PER 100 FT. SQUARE
RANGE – YARDS
6.5
6.0
5.5
5.0
4.5
4.0
3.5
0
2000
4000
6000
8000
10000
12000
14000

PERFORATIONS OF 1/8-IN. MILD STEEL

TANK GUNS



INCLINATION 0°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 0 FPS



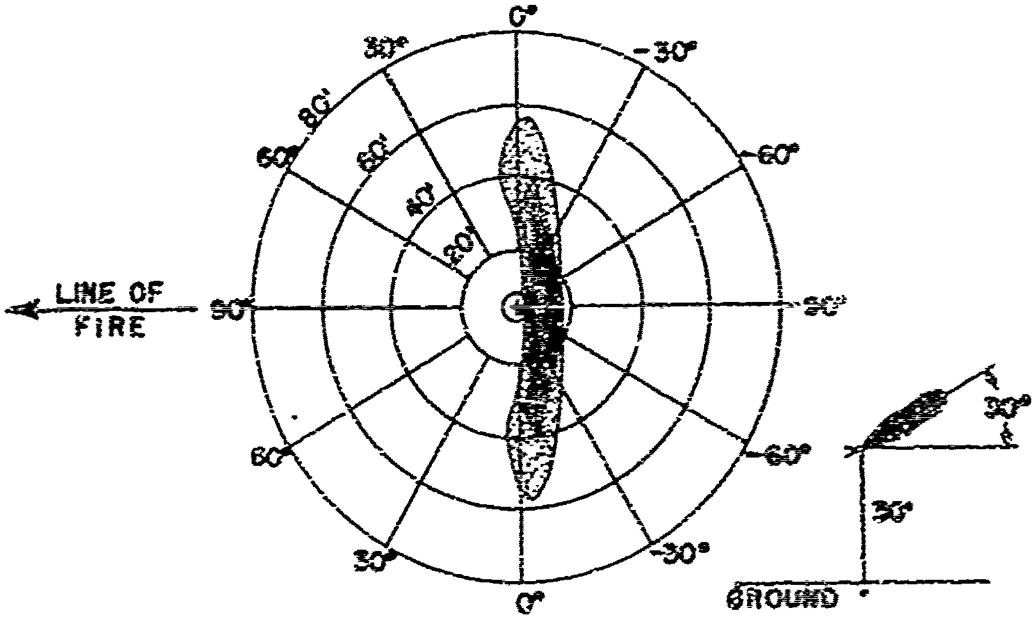
▨ AT LEAST 1 HIT PER 4 SQ FT

▨ AT LEAST 1 HIT PER 10 SQ FT

INCLINATION 30°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 800 FPS

PERFORATION OF 1/8 IN. MILD STEEL

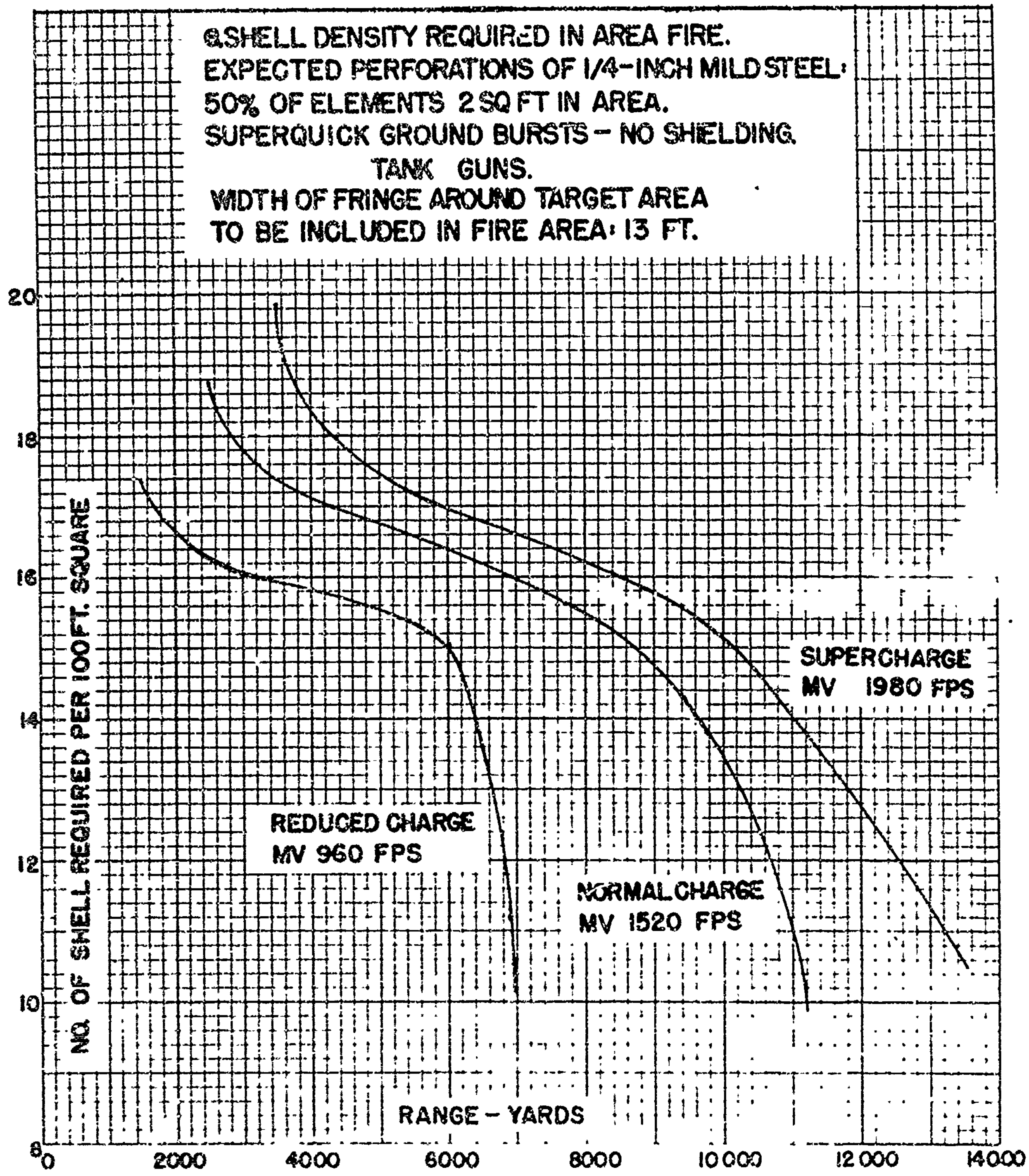
TANK GUNS

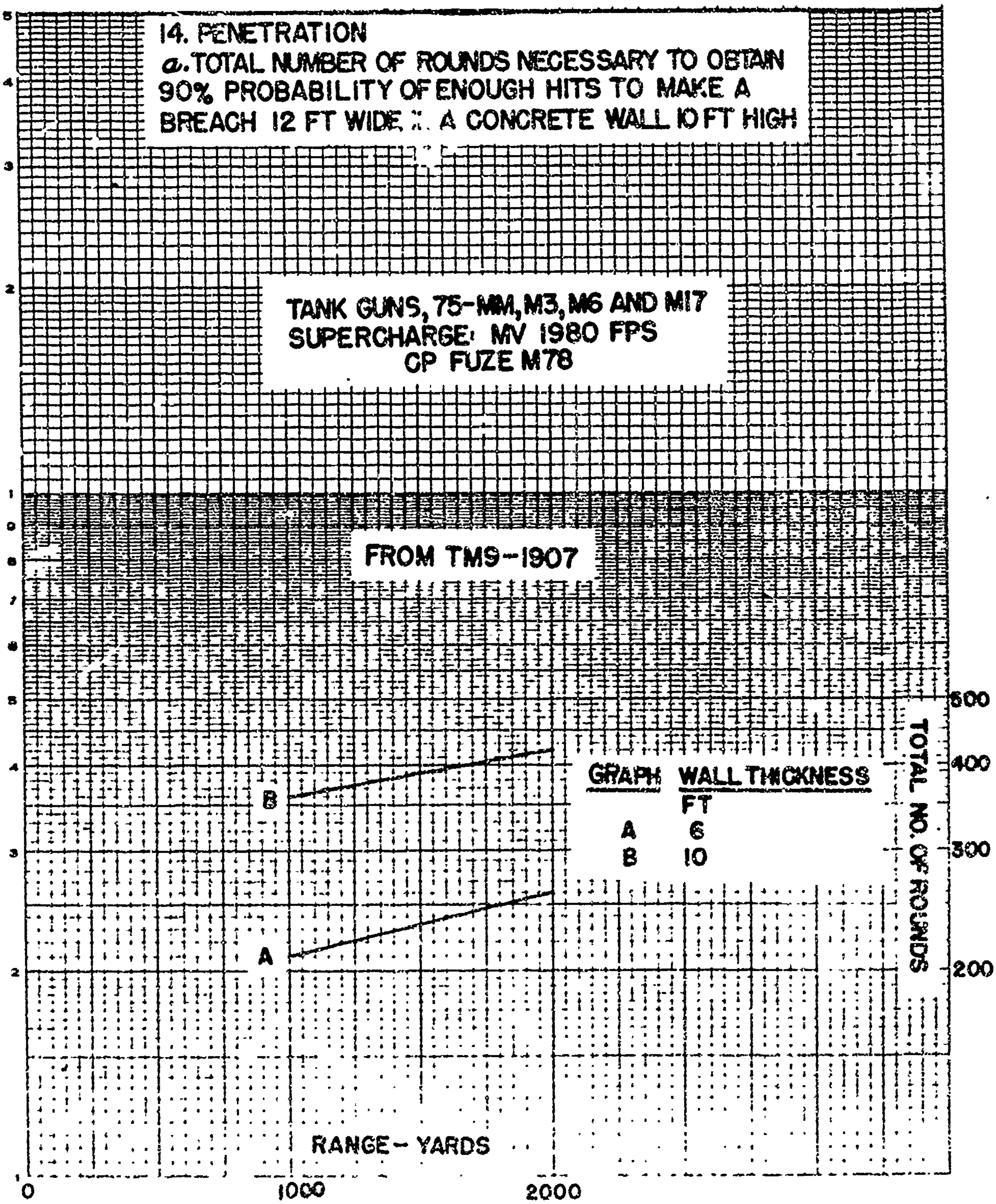


INCLINATION 30°
HEIGHT OF BURST 30 FT
REMAINING VELOCITY 800 FPS

▨ AT LEAST 1 HIT PER 10 SQ FT

░ AT LEAST 1 HIT PER 25 SQ FT


@SHELL DENSITY REQUIRED IN AREA FIRE.
EXPECTED PERFORATIONS OF 1/4-INCH MILD STEEL:
50% OF ELEMENTS 2 SQ FT IN AREA.
SUPERQUICK GROUND BURSTS – NO SHIELDING.
TANK GUNS.
WIDTH OF FRINGE AROUND TARGET AREA
TO BE INCLUDED IN FIRE AREA: 13 FT.
NO. OF SHELL REQUIRED PER 100 FT. SQUARE
20
18
16
14
12
10
8
SUPERCHARGE
MV 1980 FPS
REDUCED CHARGE
MV 960 FPS
NORMAL CHARGE
MV 1520 FPS
RANGE – YARDS
0
2000
4000
6000
8000
10 000
12 000
14000

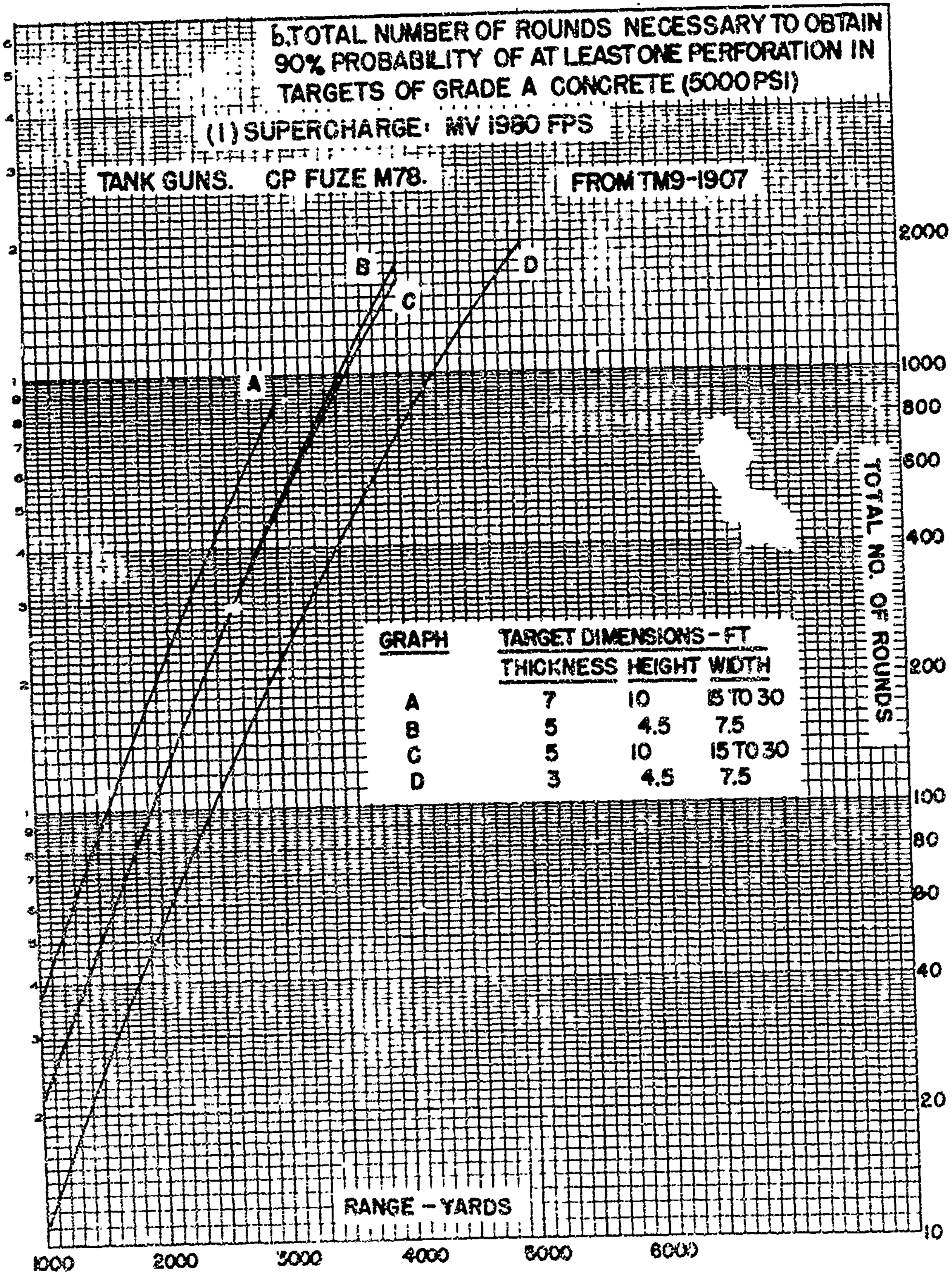


14. PENETRATION

a. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF ENOUGH HITS TO MAKE A BREACH 12 FT WIDE [illegible] A CONCRETE WALL 10 FT HIGH

TANK GUNS, 75-MM, M3, M6 AND M17
SUPERCHARGE: MV 1980 FPS
CP FUZE M78

FROM TM9-1907



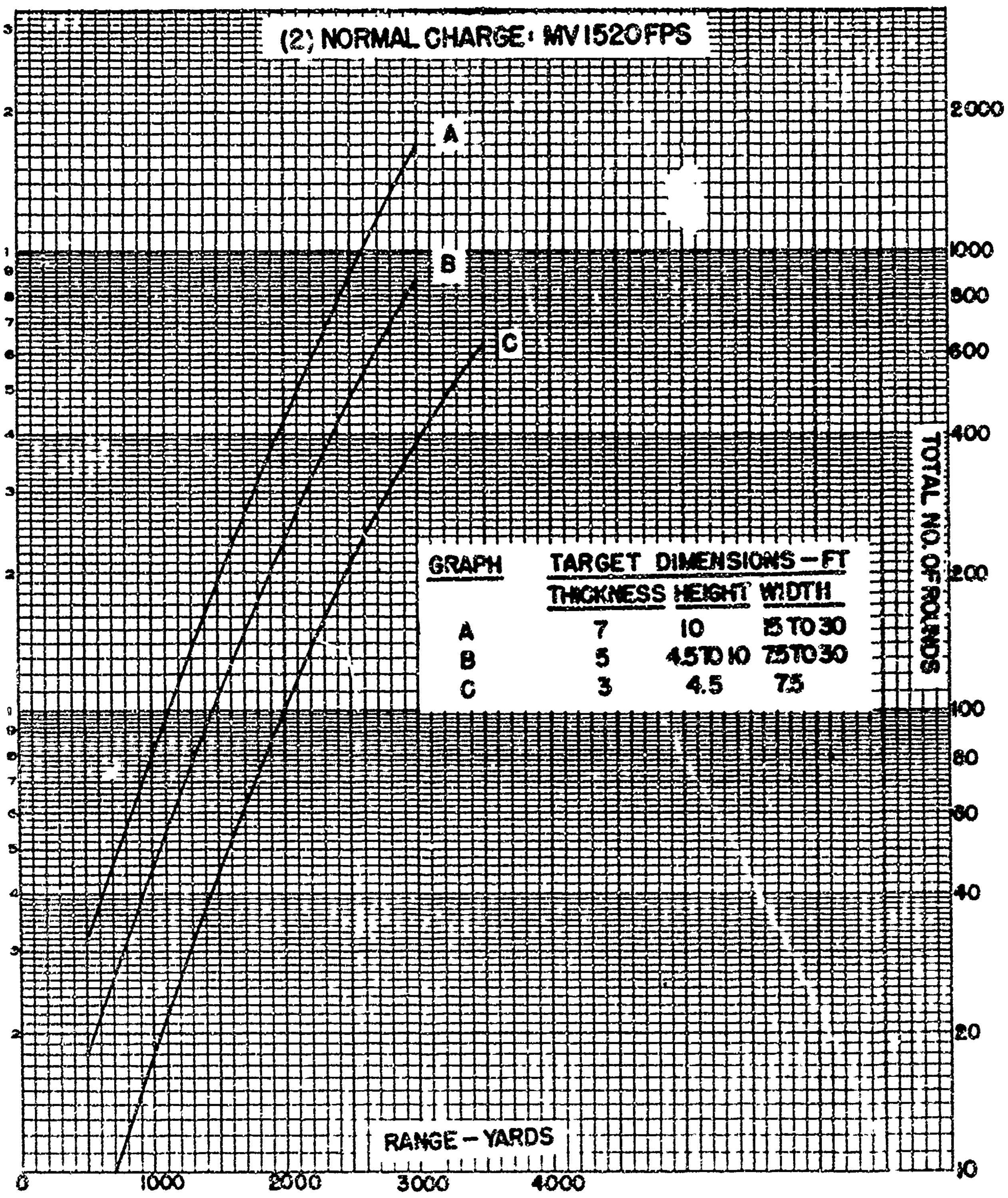
b. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF AT LEAST ONE PERFORATION IN TARGETS OF GRADE A CONCRETE (5000 PSI)

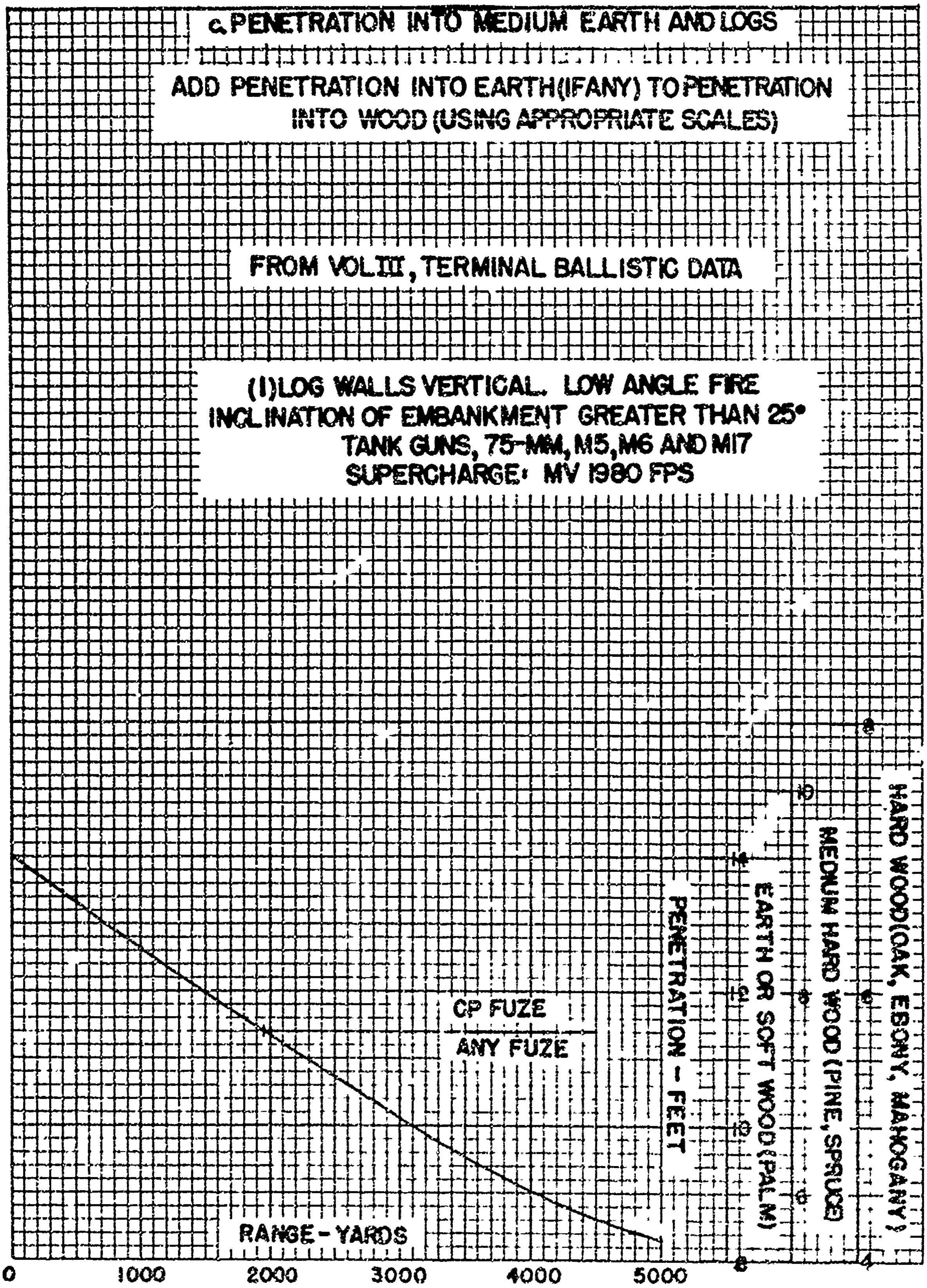
(1) SUPERCHARGE: MV 1950 FPS

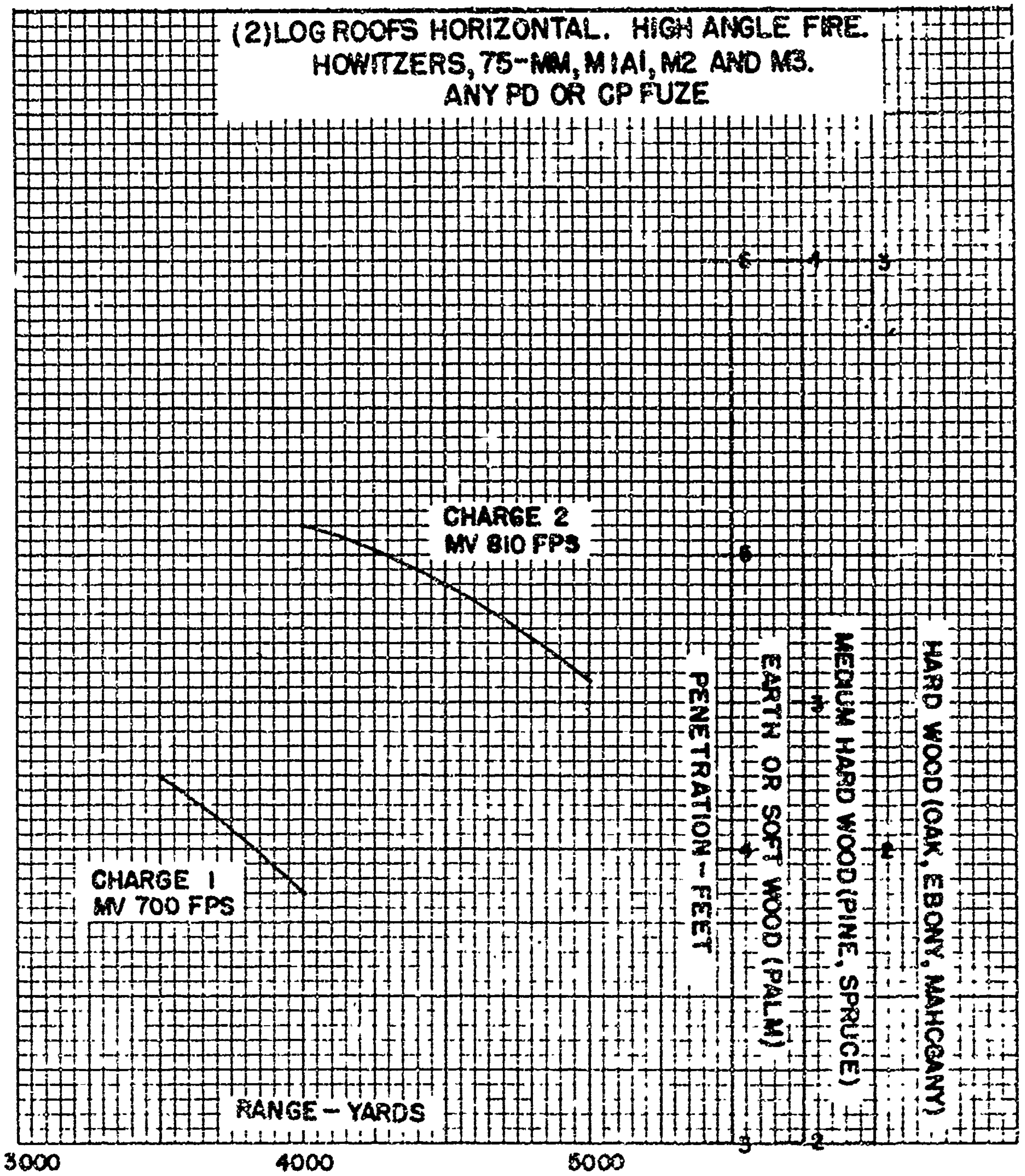
TANK GUNS. CP FUZE M78.

FROM TM9-1907

GRAPH	TARGET DIMENSIONS - FT		
	THICKNESS	HEIGHT	WIDTH
A	7	10	15 TO 30
B	5	4.5	7.5
C	5	10	15 TO 30
D	3	4.5	7.5


(2) NORMAL CHARGE: MV 1520 FPS
A
B
C
GRAPH
TARGET DIMENSIONS — FT
THICKNESS HEIGHT WIDTH
A 7 10 15 TO 30
B 5 4.5 TO 10 7.5 TO 30
C 3 4.5 7.5
TOTAL NO. OF ROUNDS
RANGE — YARDS
0
1000
2000
3000
4000
10
20
40
60
80
100
200
400
600
800
1000
2000


c. PENETRATION INTO MEDIUM EARTH AND LOGS
ADD PENETRATION INTO EARTH (IF ANY) TO PENETRATION INTO WOOD (USING APPROPRIATE SCALES)
FROM VOL III, TERMINAL BALLISTIC DATA
(1) LOG WALLS VERTICAL. LOW ANGLE FIRE
INCLINATION OF EMBANKMENT GREATER THAN 25°
TANK GUNS, 75-MM, M5, M6 AND M17
SUPERCHARGE: MV 1980 FPS
CP FUZE
ANY FUZE
RANGE - YARDS
0
1000
2000
3000
4000
5000
PENETRATION - FEET
EARTH OR SOFT WOOD (PALM)
MEDIUM HARD WOOD (PINE, SPRUCE)
HARD WOOD (OAK, EBONY, MAHOGANY)
10
0
4


(2)LOG ROOFS HORIZONTAL. HIGH ANGLE FIRE.
HOWITZERS, 75-MM, M1A1, M2 AND M3.
ANY PD OR CP FUZE
CHARGE 2
MV 810 FPS
CHARGE 1
MV 700 FPS
RANGE — YARDS
PENETRATION — FEET
EARTH OR SOFT WOOD (PALM)
MEDIUM HARD WOOD (PINE, SPRUCE)
HARD WOOD (OAK, EBONY, MAHOGANY)
6
4
3
5
3
4
4
3
2
3000
4000
5000

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 75-1-61

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
9 March 1949

# BALLISTIC AND ENGINEERING DATA
for
Projectile, APC, 75-mm, M61A1
with
Fuze, BD, M66A1

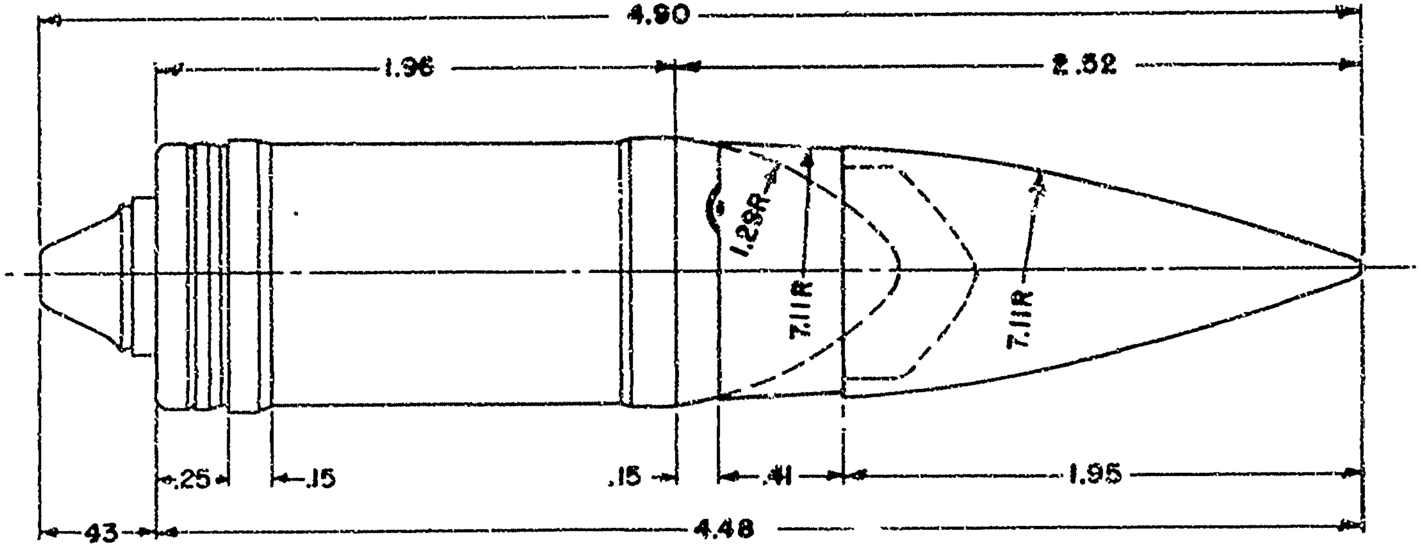
Section		Paragraph
I	General - - - - - - - - - - -	1
II	Description - - - - - - - - - -	2 - 4
III	Interior ballistic data - - - - -	5
IV	Exterior ballistic data - - - -	6 - 7
V	Effect data- - - - - - - - - - -	8

SECTION I

GENERAL

	Paragraph
Purpose -	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise [illegible] of information regarding the shape, dynamics, ballistics and effects of the 75-mm Armor-pierc[illegible]apped Projectile M61A1 with the Base Detonating Fuze M66A1, which contains a tracer composition. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.



ALL DIMENSIONS IN CALIBERS

1CAL=2.953"

PROJECTILE, APC, 75-MM, M61A1

FUZE, BD, M66A1

SECTION II

DESCRIPTION

	Paragraph
Drawings -	2
Dimensions -	3
Physical characteristics -	4

2. Drawings.

Projectile: Metal parts assembly and details	75-2-291
Fuze: Assembly	73-2-178
Details	73-2-179 and 180

3. Dimensions.

Fuze: Length (outside)	0.43 cal
Band: Distance from base	0.25 cal
Width	0.1[illegible] cal
Body: Cylindrical length	1.98 cal
Ogival length (outside)	0.15 cal
Radius of ogival arc	1.29 cal
Cap: Length (outside)	0.41 cal
Radius of ogival arc	7.11 cal
Windshield: Length	1.95 cal
Radius of ogival arc	7.11 cal
Length: Ogive	2.52 cal
Projectile without fuze	4.48 cal
Projectile and fuze	4.90 cal

4. Physical characteristics.

Weight (standard)	14.90 lb
Base of projectile to center of gravity	1.428 cal*
Axial moment of inertia	15.80 lb.in^2 *
Transverse moment of inertia	105.7 lb.in^2 *

* Estimated from the values for the 3-inch APC Projectile M62.

SECTION III

INTERIOR BALLISTIC DATA

Paragraph
Theoretical yaw in bore - 5

5. Theoretical yaw in bore.

Minimum	11 min
Maximum	16 min

SECTION IV

EXTERIOR BALLISTIC DATA

Paragraph
Aerodynamic data - 6
Firing table data - 7

6. Aerodynamic data.

a. Drag. A form factor of 0.985 relative to the G_6 drag function was determined by resistance firings at velocities of 1643 and 2007 fps. The corresponding ballistic coefficient is 1.735. At a velocity of 2030 fps, the drag coefficient is 0.146.

b. Stability. The moment coefficient, estimated from known data for the 3-inch APC Projectile [illegible] is 1.346 at a muzzle velocity of 2030 fps. The estimated stability factor is 2.68 for a twist of rifling of 1/25.586 (in Tank Guns M3, M6 and M17) and 3.60 for a twist of rifling of 1/22 (in Aircraft Guns M5A1 and M10).

c. Yawing moment coefficient. The yawing moment coefficient is 4.2. This value was calculated by an empirical formula determined by the values given in Table XIV of Ballistic Research Laboratory Report No. 357, "Damping of Calibers .30 and .50 Bullets and 37-mm HE Shell".

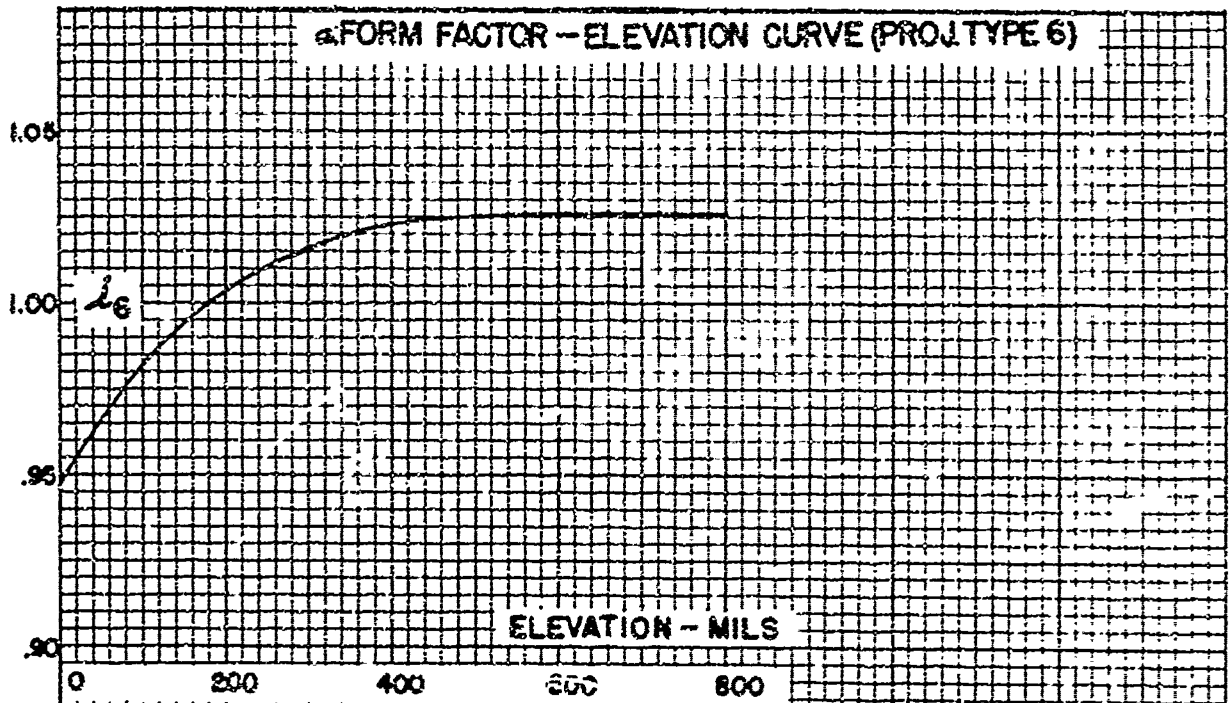
d. Cross wind force coefficient. The cross wind force coefficient is 0.256. This is the value calculated for the 3-inch 15-lb HE Shell M1915, using the drift for a range of 9000 yards in FT 3-M-2 and the velocities taken from the computed trajectory for an elevation of 10° and a muzzle velocity of 2600 fps. The 3-inch Shell M1915 and the 75-mm Projectile M61A2 are approximately the same shape.

e. **Magnus moment coefficient.** The Magnus moment coefficient, calculated by an empirical formula that applies to a large number of projectiles, is - 0.30.

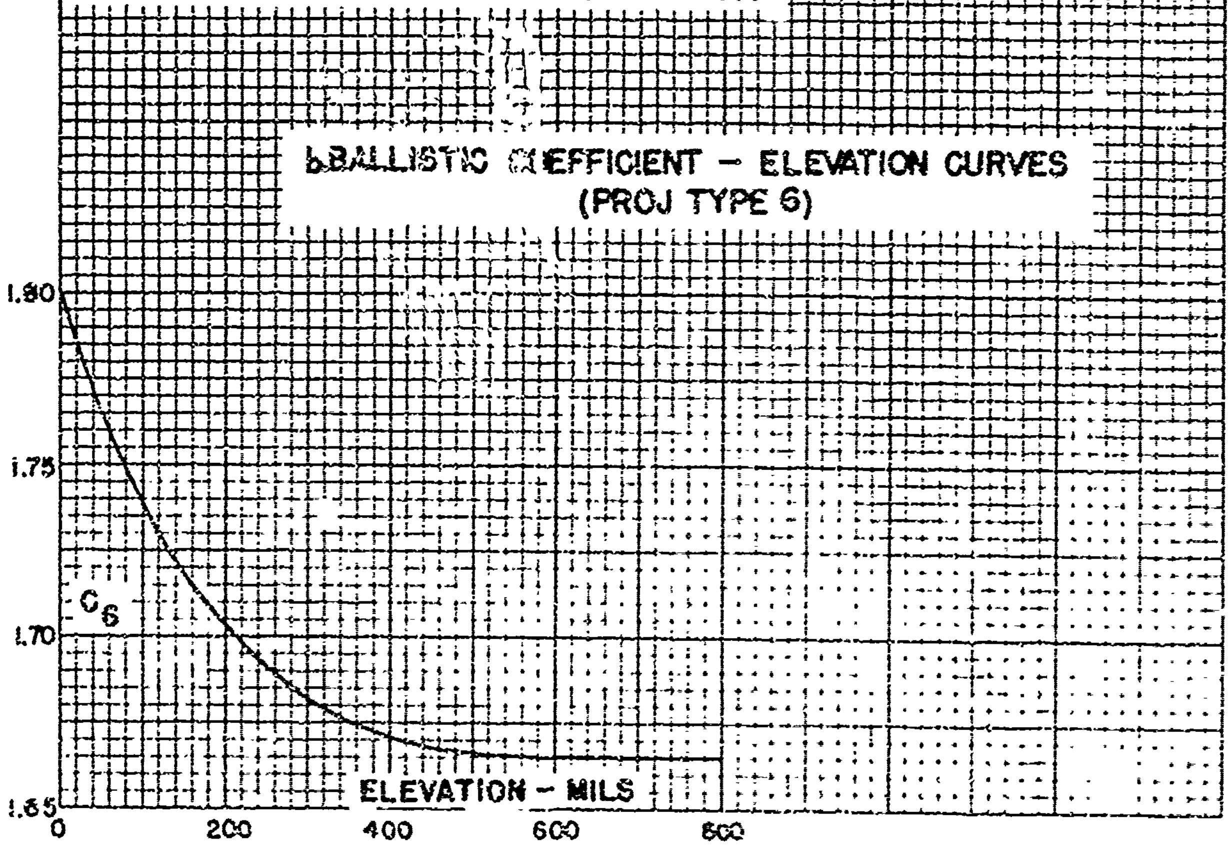
7. **Firing table data.** FT 75-AY-1.

Guns, 75-mm, M3 (mounted in Medium Tank M4 and modifications, including the Assault Tank M4A3E2) M6 and M17 (mounted in Light Tank M24). Twist of rifling: 1/25.586. MV: 2030 fps. OCM items 16119 and 16167 recommended and approved standardization of the AP Projectile M61. OCM items 16640 and 16741 recommended and approved authorization for its use in the 75-mm Tank Gun M2, which is now obsolete. OCM item 17699 changed its designation from Armor-piercing to Armor-piercing Capped Projectile.

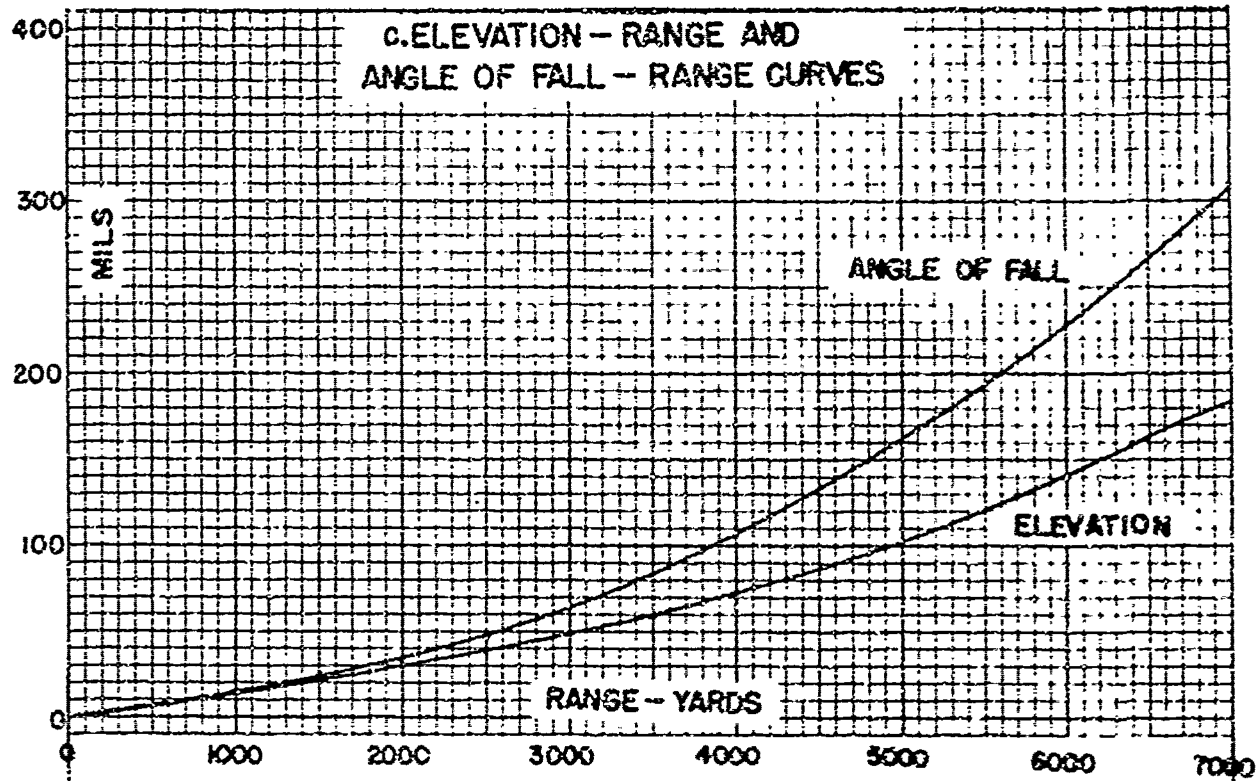
NOTE: OCM items 20756 and 20991 recommended and approved authorization for the use of the APC Projectile M61 in the 75-mm Aircraft Gun M4, which is rifled with a twist of 1/25.586 and is now obsolete, and FT 75AC-AX-2 gives firing table data for this materiel. The APC Projectile M61A1 is now standard ammunition for the 75-mm Aircraft Guns M5A1 and M10, which are rifled with a twist of 1/22, but no firing tables have been prepared for this combination of guns and ammunition.



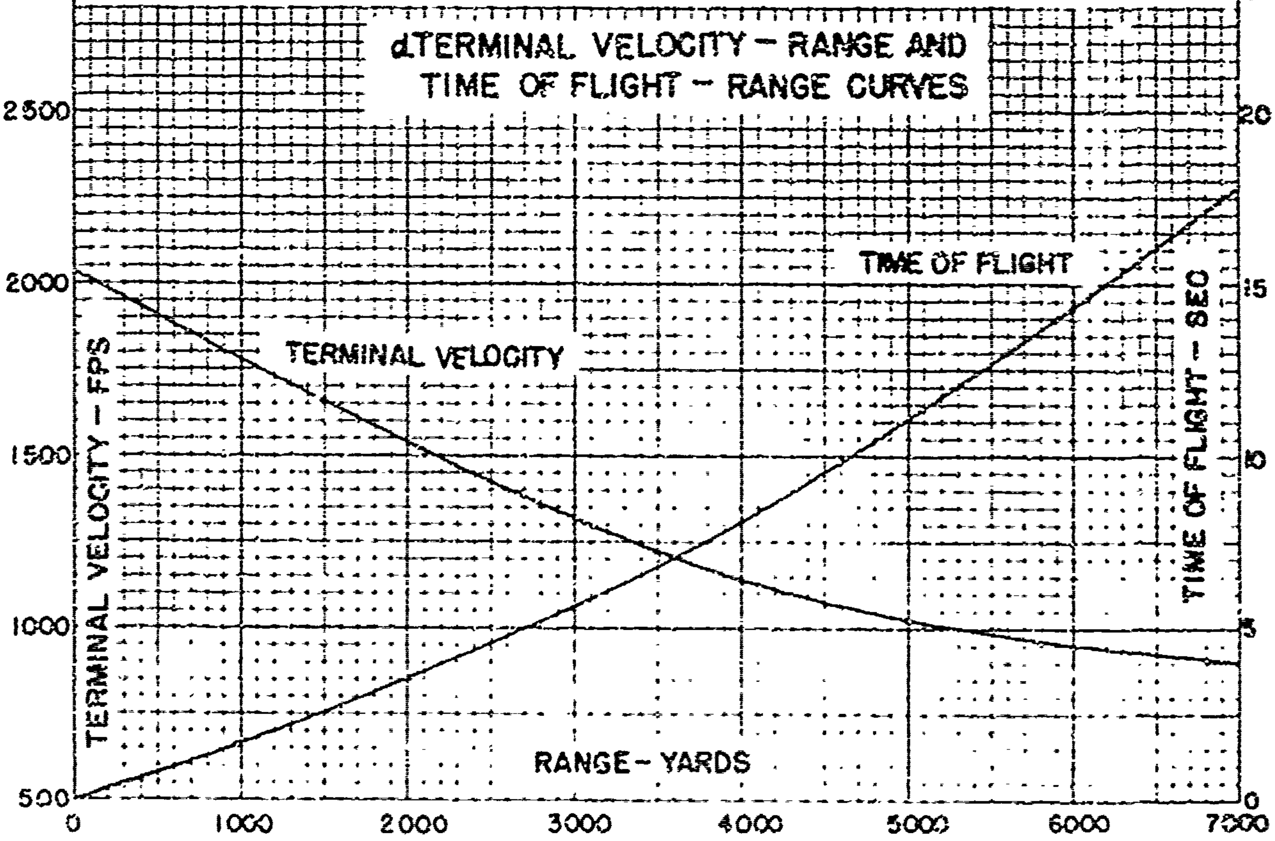
a. FORM FACTOR – ELEVATION CURVE (PROJ. TYPE 6)



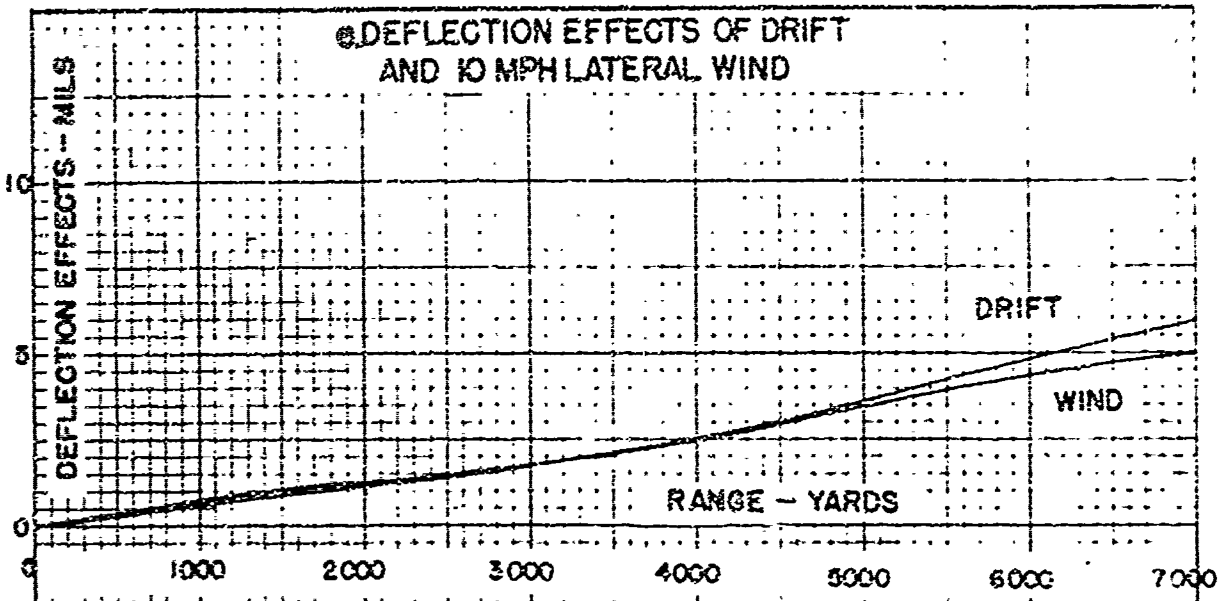
b. BALLISTIC COEFFICIENT – ELEVATION CURVES (PROJ TYPE 6)

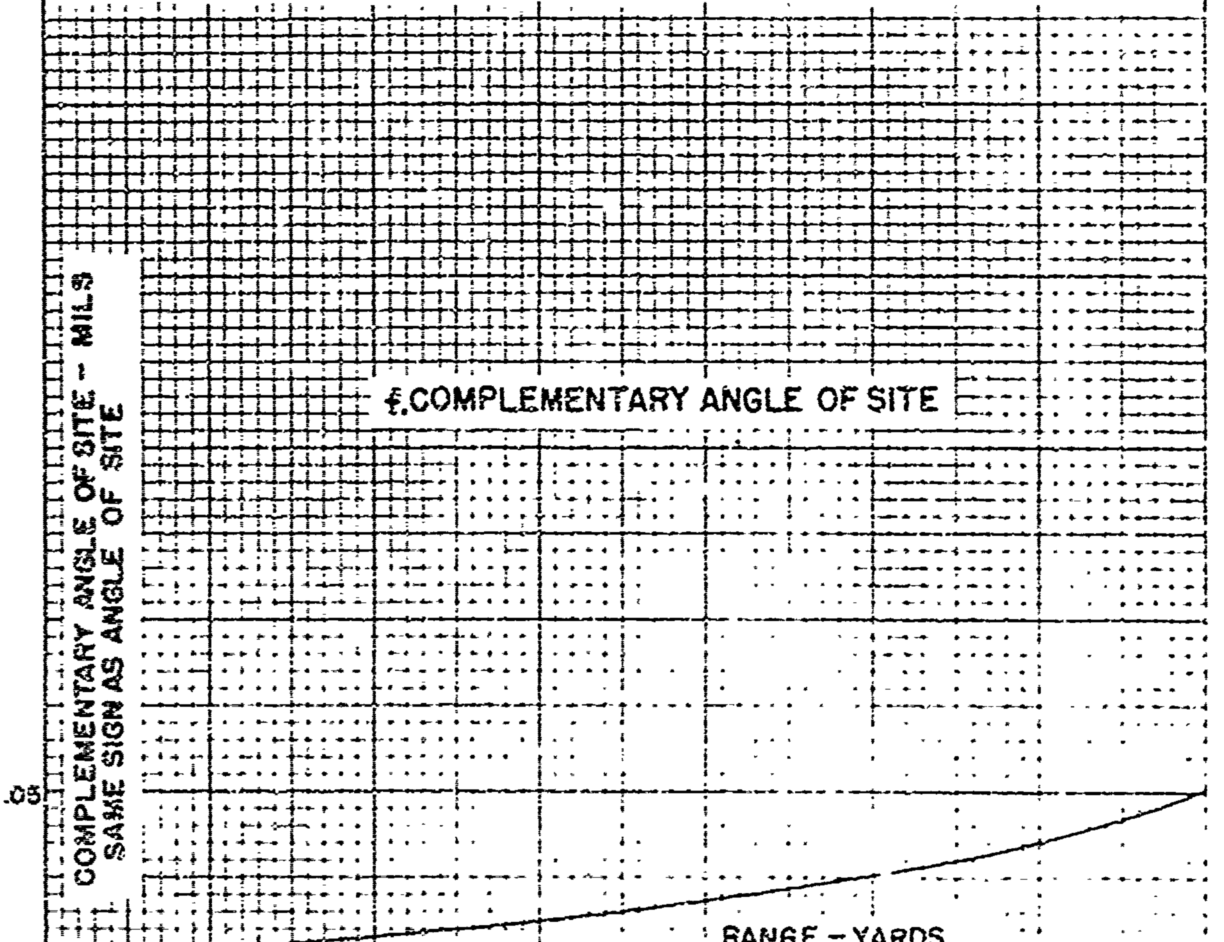


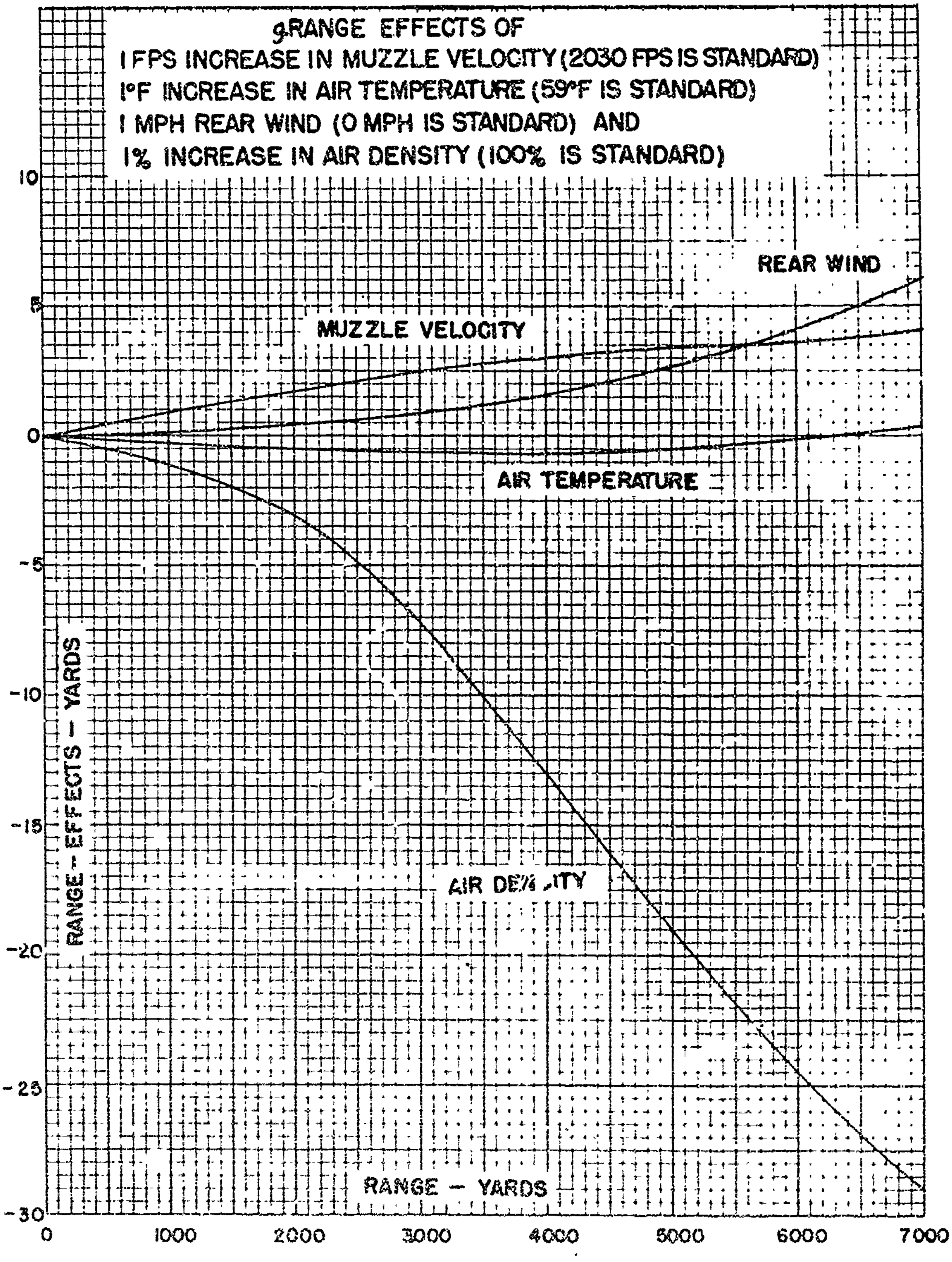
c. ELEVATION — RANGE AND ANGLE OF FALL — RANGE CURVES



d. TERMINAL VELOCITY — RANGE AND TIME OF FLIGHT — RANGE CURVES


e. DEFLECTION EFFECTS OF DRIFT AND 10 MPH LATERAL WIND


f. COMPLEMENTARY ANGLE OF SITE


RANGE EFFECTS OF
1 FPS INCREASE IN MUZZLE VELOCITY (2030 FPS IS STANDARD)
1°F INCREASE IN AIR TEMPERATURE (59°F IS STANDARD)
1 MPH REAR WIND (0 MPH IS STANDARD) AND
1% INCREASE IN AIR DENSITY (100% IS STANDARD)
REAR WIND
MUZZLE VELOCITY
AIR TEMPERATURE
AIR DENSITY
RANGE - EFFECTS - YARDS
RANGE - YARDS
10
5
0
-5
-10
-15
-20
-25
-30
0
1000
2000
3000
4000
5000
6000
7000

SECTION V

EFFECT DATA

Paragraph
Penetration- 8

8. Penetration.

a. Ballistic limits.

Plate			Ballistic Limit		Number in
Type	Thickness inches	Obliquity deg	Type	fps	Average
Face Hardened	3	20	Navy	1658	41
	3	30		1507	3
	3.5	20		1834	2
	2	20	Army	1487	-
	2	30		1699	1
	3.125	20		1734	8
	3.0625	20		1738	28
Homo-geneous	2.5	20	Army	1744	1
	3	0		1594	1
	3	0	Navy	1797	6
	3	20		1925	26

b. **Vulnerability of German tanks.** The following data on vulnerability of German tanks (Panzerkampfwagen) to APC Projectile M61A1, fired from Tank Guns M3, M6 and M17 at a muzzle velocity of 2030 fps, were taken from TM 9-1907, "Ballistic Data, Performance of Ammunition".

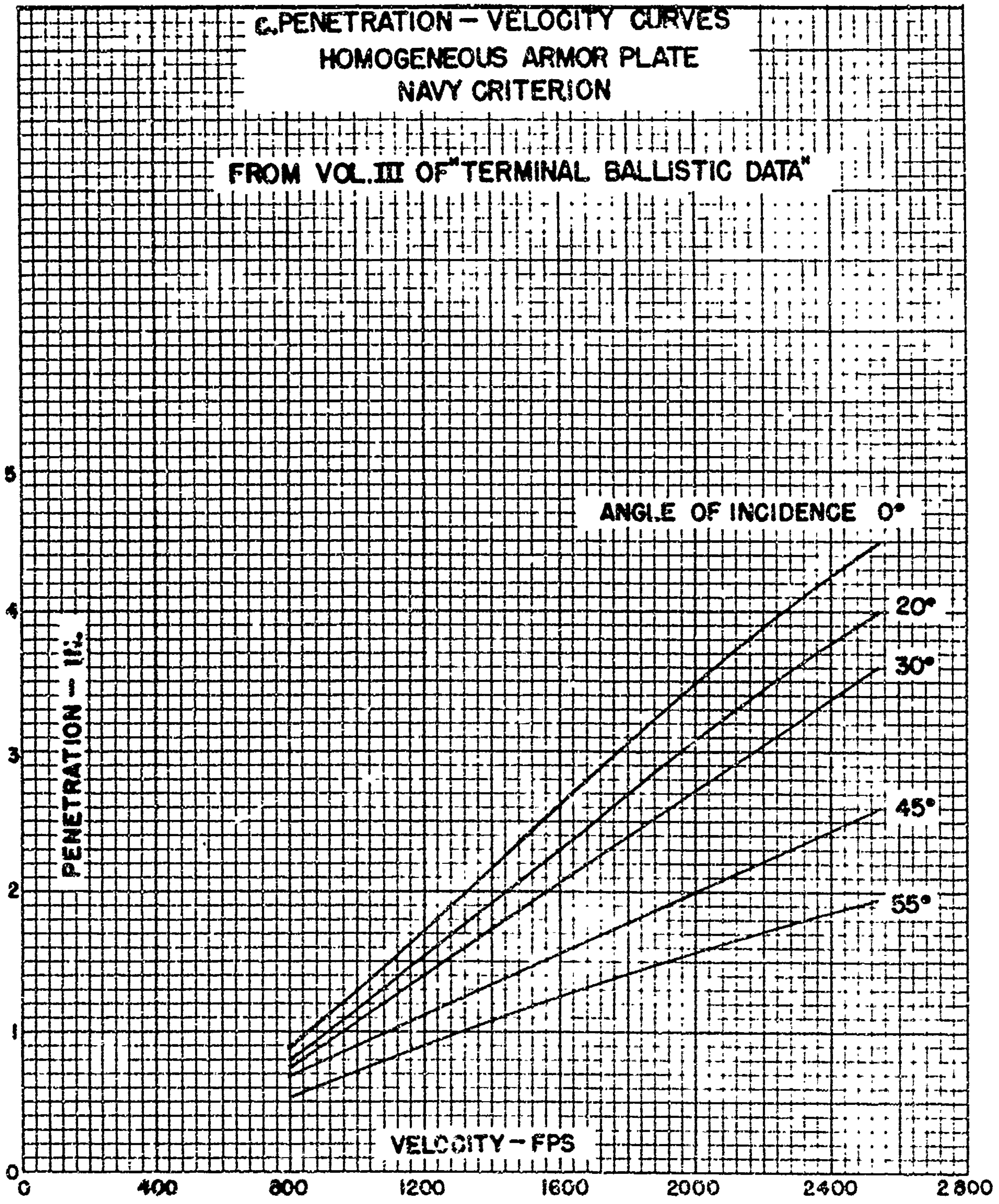
MAXIMUM VULNERABLE RANGE - YARDS

Tank	III		IV		VI	
Attack Angle	0°	25°	0°	25°	0°	25°
Frontal						
Turret Sides	3860	4700	3860	4700	1000	----
Turret Front	2250	1120	2500	1280	----	----
Upper Hull Front	1400	----	1470	----	----	----
Lower Hull Front	720	----	1200	----	----	----
Flank						
Turret Rear	5000	4500	4700	3760	1000	----
Turret Sides	3860	4700	3860	4700	1000	----
Turret Front	2250	1120	2500	1280	----	----
Upper Hull Sides	5000+	4960	5000+	4960	1000	----
Lower Hull Sides	5000+	4960	5000+	4960	2200	1200
Rear						
Turret Rear	5000	4500	4700	3760	1000	----
Turret Sides	3860	4700	3860	4700	1000	----
Turret Front	2250	1120	2500	1280	----	----
Upper Hull Rear	2110	1040	5000+	4960	300	----
Lower Hull Rear	2500	1280	5000+	4960	300	----

b. **Vulnerability of German tanks.** The following data on vulnerability of German tanks (Panzerkampfwagen) to APC Projectile M61A1, fired from Tank Guns M3, M6 and M17 at a muzzle velocity of 2030 fps, were taken from TM 9-1907, "Ballistic Data, Performance of Ammunition".

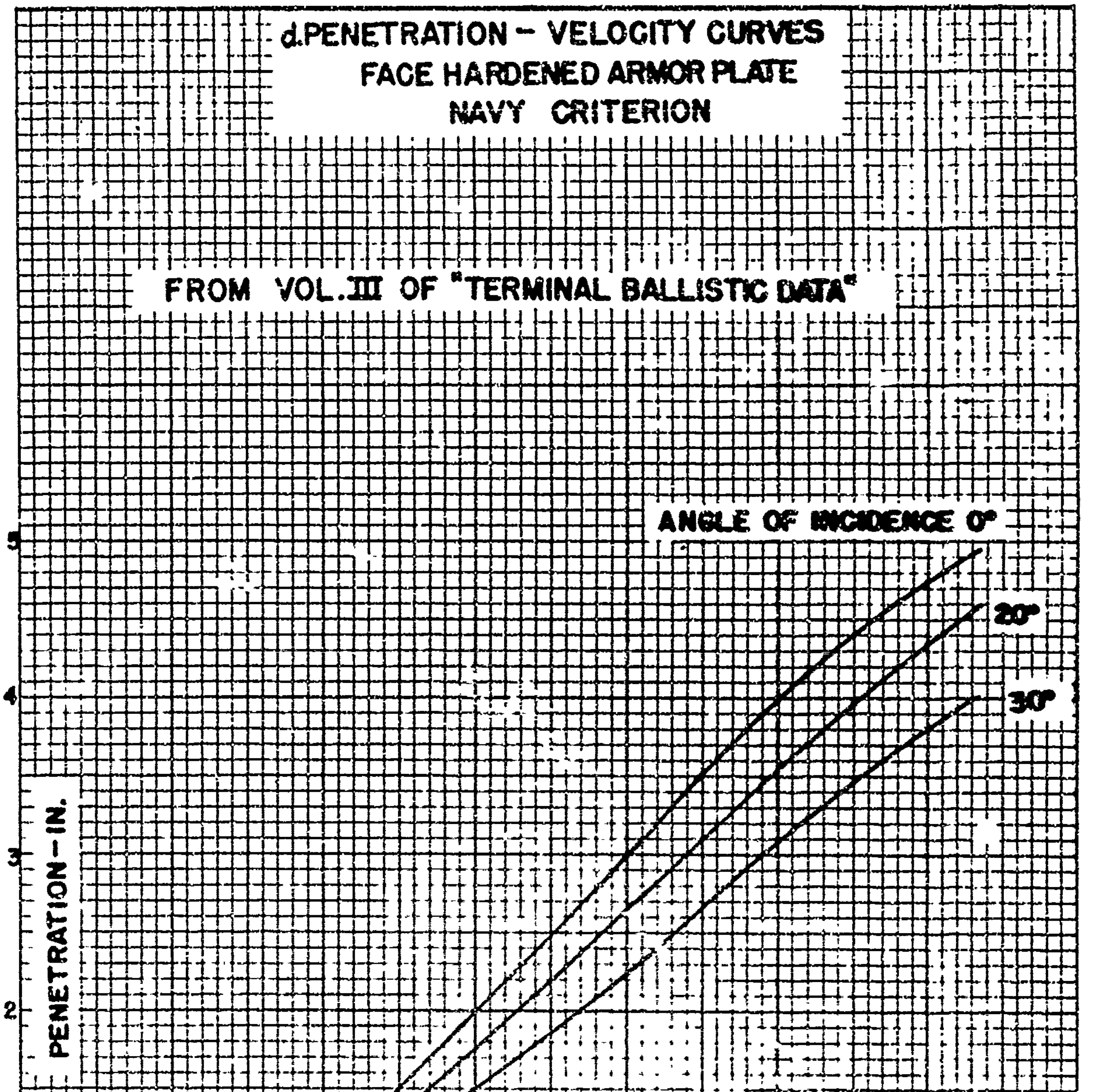
MAXIMUM VULNERABLE RANGE - YARDS

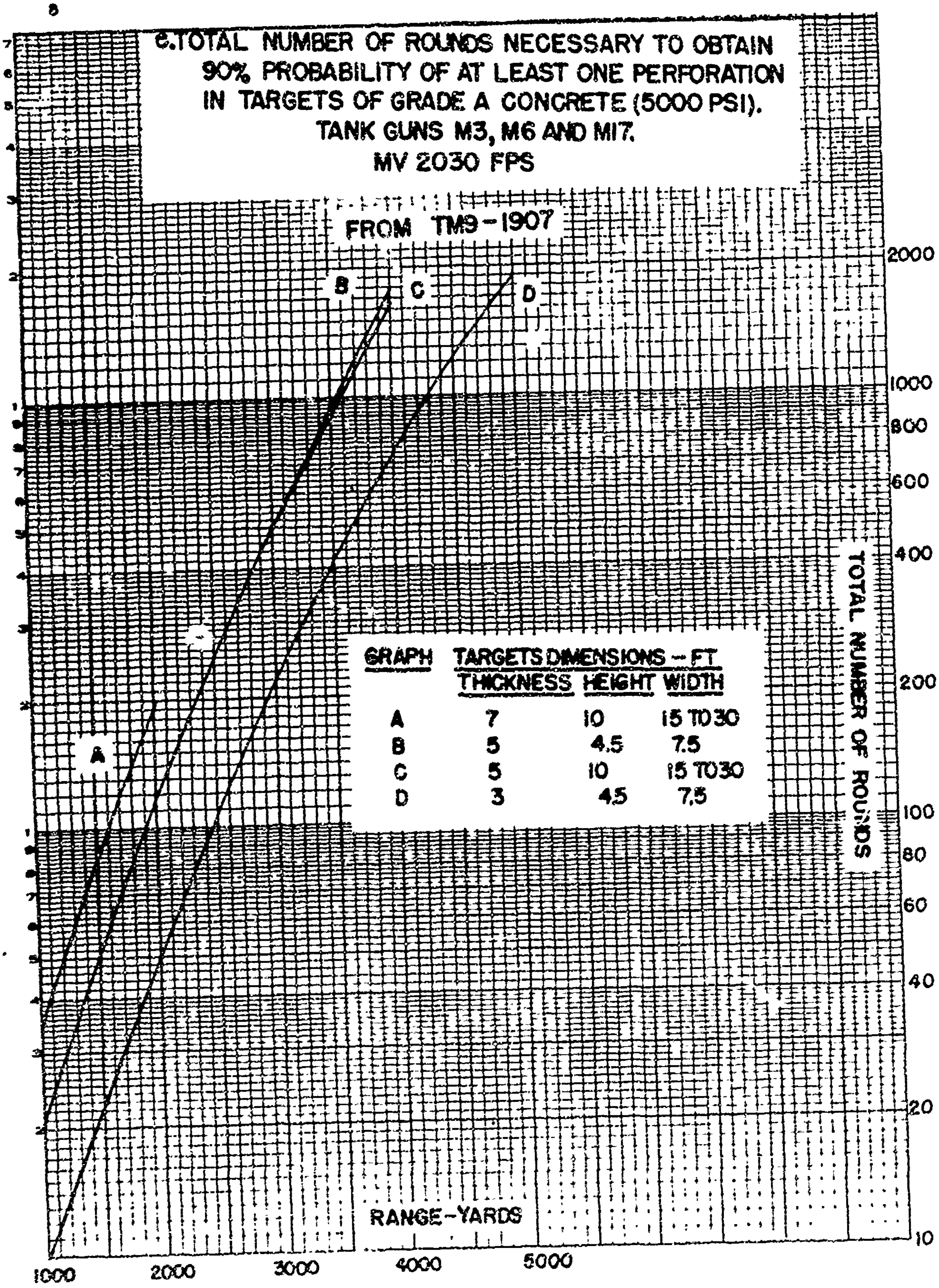
Tank	III		IV		VI	
Attack / Angle	0°	25°	0°	25°	0°	25°
Frontal						
Turret Sides	3860	4700	3860	4700	1000	----
Turret Front	2250	1120	2500	1280	----	----
Upper Hull Front	1400	----	1470	----	----	----
Lower Hull Front	720	----	1200	----	----	----
Flank						
Turret Rear	5000	4500	4700	3760	1000	----
Turret Sides	3860	4700	3860	4700	1000	----
Turret Front	2250	1120	2500	1280	----	----
Upper Hull Sides	5000+	4960	5000+	4960	1000	----
Lower Hull Sides	5000+	4960	5000+	4960	2200	1200
Rear						
Turret Rear	5000	4500	4700	3760	1000	----
Turret Sides	3860	4700	3860	4700	1000	----
Turret Front	2250	1120	2500	1280	----	----
Upper Hull Rear	2110	1040	5000+	4960	300	----
Lower Hull Rear	2500	1280	5000+	4960	300	----



c. PENETRATION — VELOCITY CURVES
HOMOGENEOUS ARMOR PLATE
NAVY CRITERION

FROM VOL. III OF "TERMINAL BALLISTIC DATA"

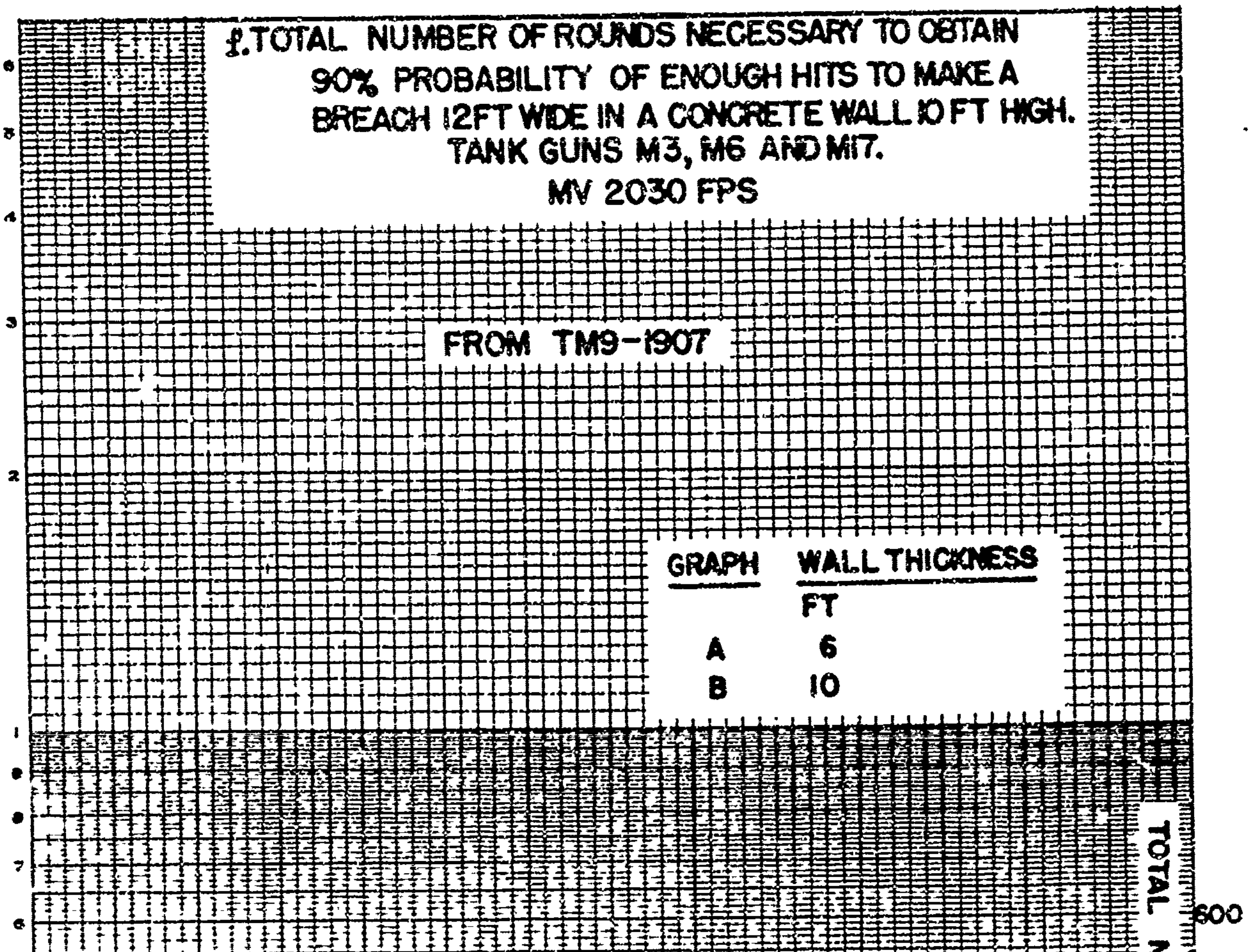

d.PENETRATION – VELOCITY CURVES
FACE HARDENED ARMOR PLATE
NAVY CRITERION
FROM VOL.III OF "TERMINAL BALLISTIC DATA"
ANGLE OF INCIDENCE 0°
20°
30°
PENETRATION – IN.
0
1
2
3
4
5
VELOCITY – FPS
0
400
800
1200
1600
2000
2400
2800



e. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF AT LEAST ONE PERFORATION IN TARGETS OF GRADE A CONCRETE (5000 PSI).
TANK GUNS M3, M6 AND M17.
MV 2030 FPS

FROM TM9-1907

GRAPH	TARGETS DIMENSIONS – FT		
	THICKNESS	HEIGHT	WIDTH
A	7	10	15 TO 30
B	5	4.5	7.5
C	5	10	15 TO 30
D	3	4.5	7.5



f. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF ENOUGH HITS TO MAKE A BREACH 12 FT WIDE IN A CONCRETE WALL 10 FT HIGH. TANK GUNS M3, M6 AND M17. MV 2030 FPS

FROM TM9-1907

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 75-1-66

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
9 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HEAT, 75-mm, M66
with
Fuzes, BD, M62A1 and M91

Section		Paragraph
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 8
V	Effect data	9

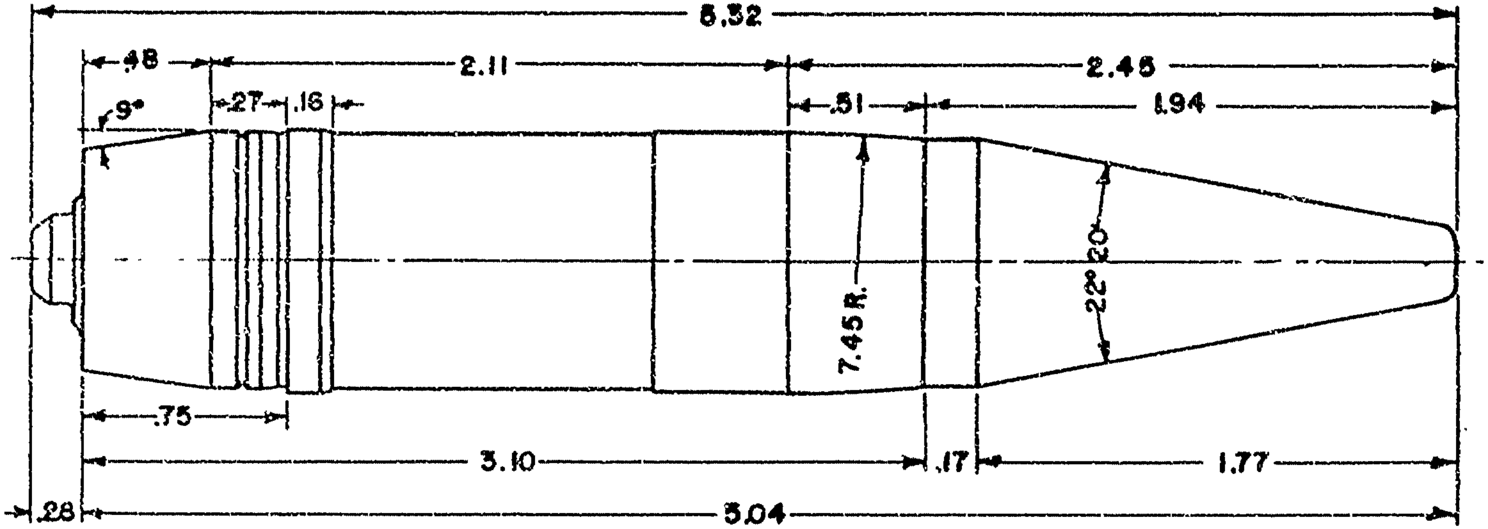
SECTION I

GENERAL

	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 75-mm High Explosive Antitank Shell M66 with the Base Detonating Fuzes M62A1 and M91. This information is collected from the drawings, reports, and firing tables pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL. = 2.953"



SHELL, HEAT, 75-MM, M66
FUZE, BD, M91

SECTION II

DESCRIPTION

Paragraph

Drawings - 2
Dimensions - 3
Physical characteristics - 4

2. Drawings.

Shell:	Metal parts, assembly and details	75-2-314
	Ogive assembly, cone and details	75-2-315
Fuze, BD, M62A1:	Assembly	73-2-168
	Details	73-2-169, 170 and 171
Fuze, BD, M91:	Assembly	73-2-239
	Details	73-2-169, 170 and 240

3. Dimensions.

Fuze, BD, M91:	Length (outside)	0.28 cal
Boattail:	Angle	9°00'
	Length	0.48 cal
Band:	Distance from boattail	0.27 cal
	Distance from base	0.75 cal
	Width	0.16 cal
Body:	Length of cylindrical part	2.11 cal
	Length of ogival part	0.51 cal
	Radius of arc	7.45 cal
Union:	Length	0.17 cal
Ogive:	Length	1.77 cal
	Angle	22°20'
Length:	Body	3.10 cal
	Ogive and union	1.94 cal
	Shell	5.04 cal
Ogive, union, and ogival part of body		2.45 cal
Shell and Fuze M91		5.32 cal

Note: Fuze, BD, M62A1 is entirely inside of shell body.

4. Physical characteristics.

Fuze	BD M62A1	BD M91
Weight (standard)	13.17 lb	13.37 lb
Base to center of gravity	1.656 cal	
Axial moment of inertia	16.75 lb.in^2	
Transverse moment of inertia	157.3 lb.in^2	

SECTION III

INTERIOR BALLISTIC DATA

Paragraph

Stresses - 5
Theoretical yaw in bore - 6

5. Stresses. The following table and the graphical representation on page 5 show the longitudinal, radial and tangential stress at each of three sections: (A) the rear corner of the band seat, (B) the front of the band seat, and (C) immediately behind the bourrelet.

Howitzer, 75-mm	M1A1, M2, M3
Twist of rifling	1/20
Cross-sectional area of bore	7.004 sq in.
Rated maximum pressure	26,000 psi
Total weight of projectile	13.37 lb
Muzzle velocity	1000 fps
Density of filler (pentolite)	0.0574 lb per cu in.

Resultant Stress* 100 psi	Section A	Section B	Section C
Longitudinal	- 162	- 358	-210
Radial	+ 364	- 3	+ 5
Tangential	- 643	+ 292	+ 171

* + denotes tension, - denotes compression.

6. Theoretical yaw in bore.

Minimum	9 min
Maximum	13 min

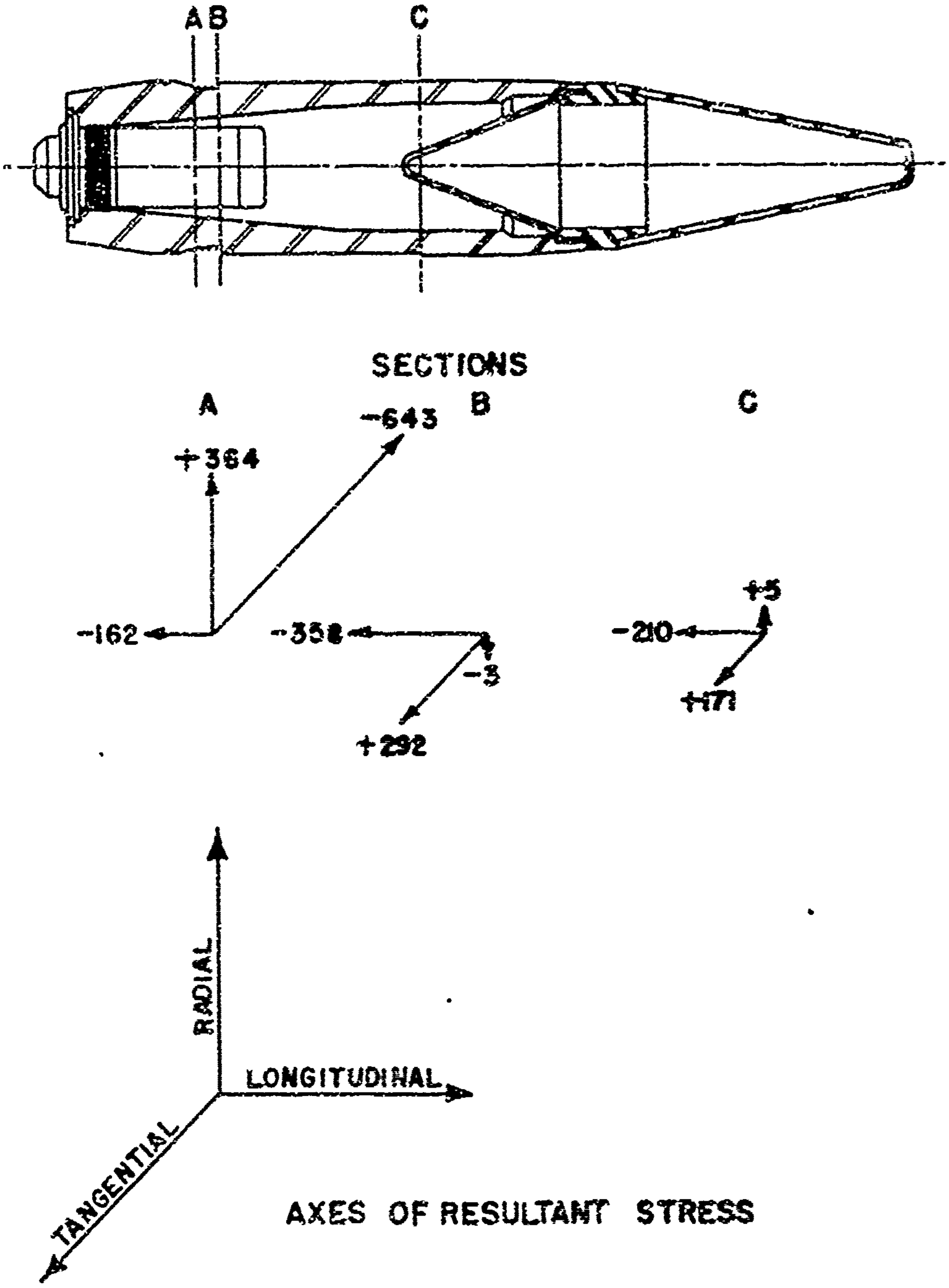


DIAGRAM OF RESULTANT STRESSES

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data -	7
Firing table data -	8

7. Aerodynamic data.

a. Drag. The form factor relative to Projectile Type 2, determined by resistance firings, and the corresponding ballistic coefficient and drag coefficient are given below.

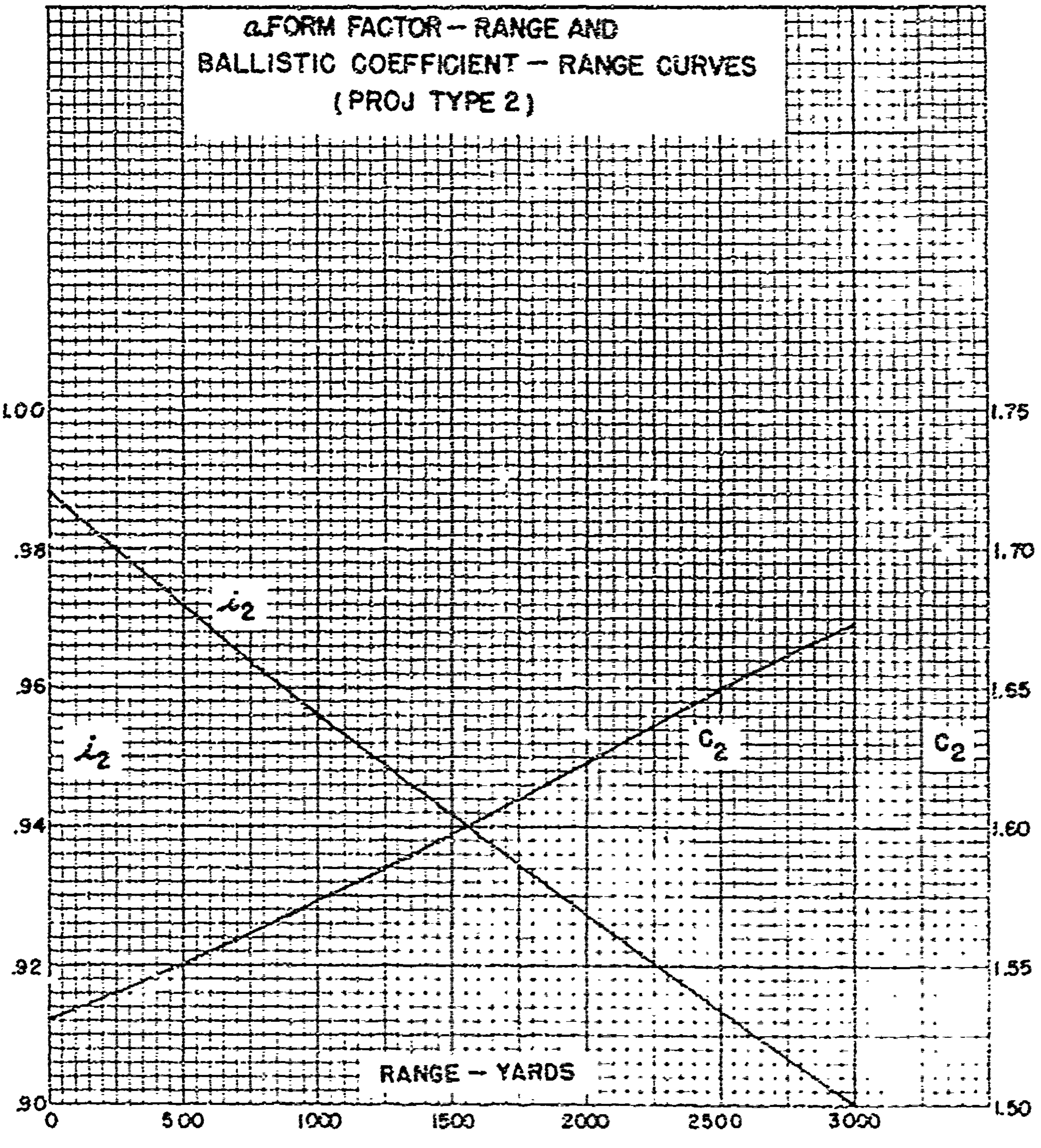
Velocity fps	Form Factor	Ballistic Coefficient	Drag Coefficient
775	.75	2.01	.050
1000	.98	1.5[illegible]	.070

b. Stability. The stability factor was determined from firings in a 75-mm Gun with a twist of rifling of 1/25.586 at a muzzle velocity of 1000 fps. The resulting stability factor is 1.22, and the moment coefficient is 2.26. With a twist of rifling of 1/20 (in the Howitzers M1A1, M2 and M3) at the same velocity, the stability factor would be 2.00.

8. Firing table data. FT 75-I-4.

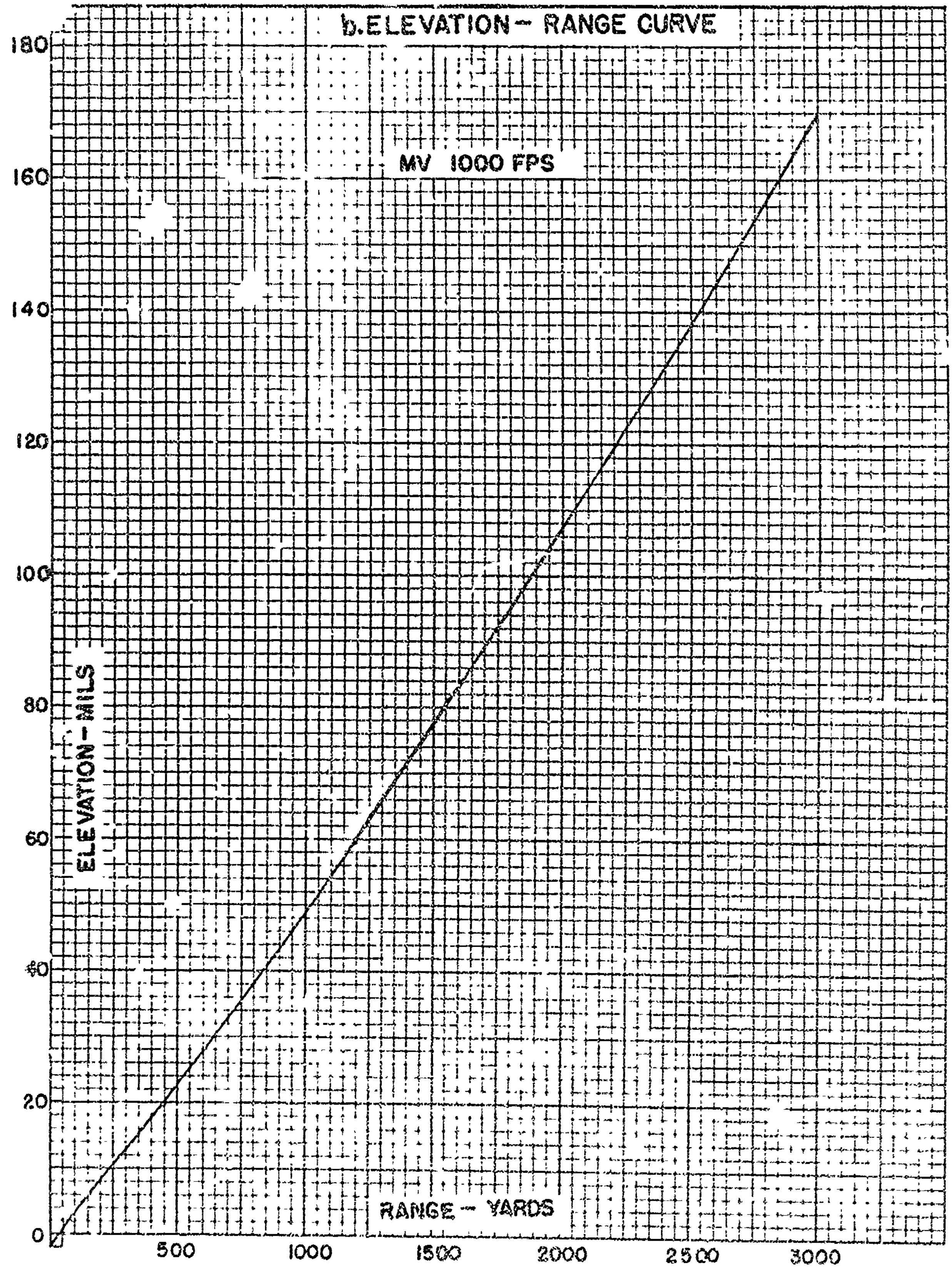
Howitzers, 75-mm, M1A1, M2 and M3. Twist of rifling: 1/20. Muzzle velocity: 1000 fps. Projectile weight: 13.10 lb. OCM items 17638 and 17752 recommended and approved standardization of the HEAT Shell M66.

The terminal velocity was taken from Ballistic Research Laboratory Memorandum Report No. 296, "Tables of Impact Velocities for Mobile Artillery Weapons".

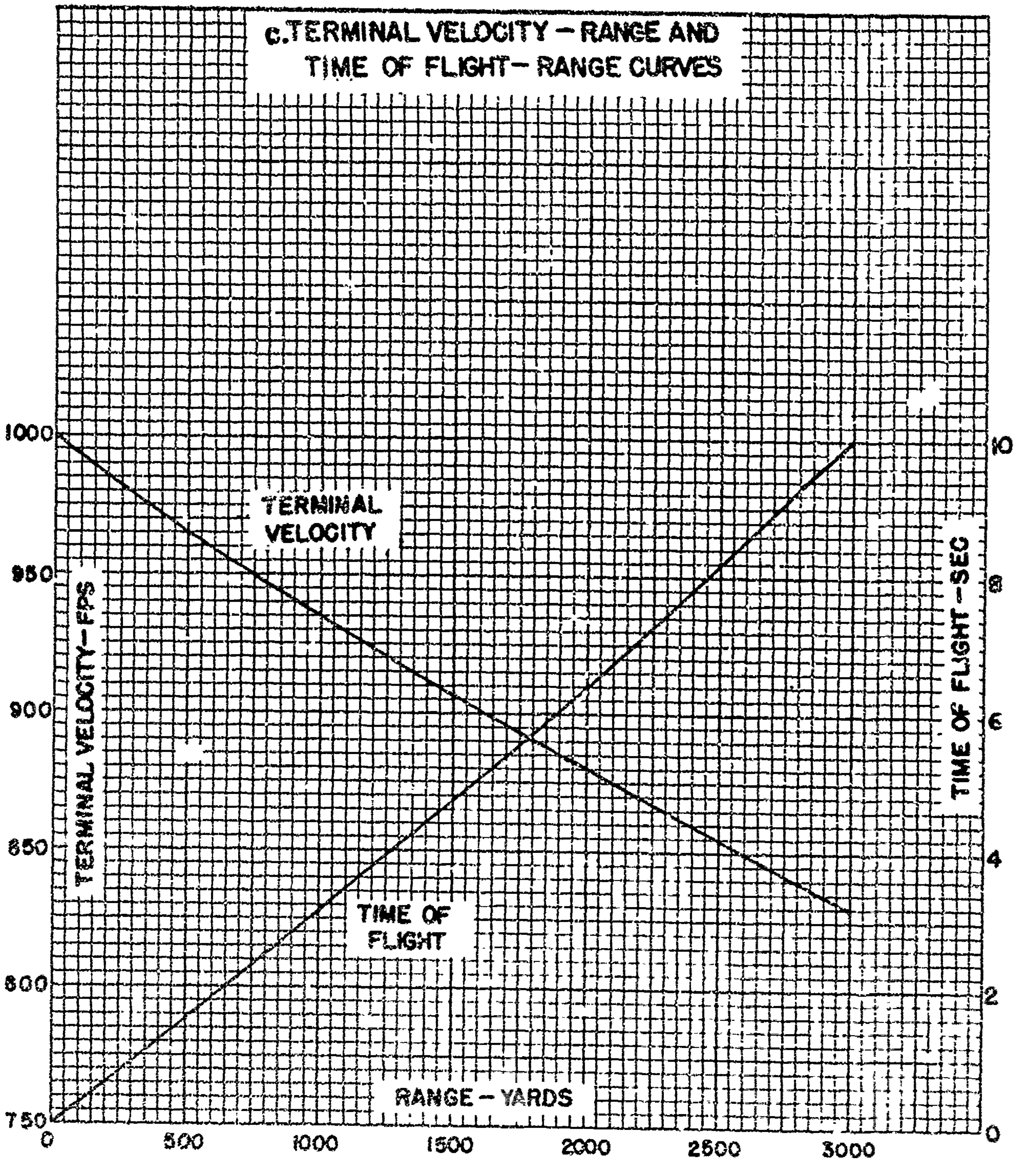


i₂ FORM FACTOR — RANGE AND
BALLISTIC COEFFICIENT — RANGE CURVES
(PROJ TYPE 2)

b. ELEVATION – RANGE CURVE



c. TERMINAL VELOCITY – RANGE AND TIME OF FLIGHT – RANGE CURVES



SECTION V

EFFECT DATA

Paragraph
Penetration- 9

9. **Penetration.** The average penetration of homogeneous armor plate by 75-mm HEAT Shell M66 is 3 inches.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 75-1-309

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
8 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 75-mm, M309
with
Fuze, PD, M48A2 or M51A4

Section — Paragraph
I General - - - - - - - - - - - - - 1
II Description - - - - - - - - - - - 2 - 4
III Interior ballistic data - - - - - - 5
IV Exterior ballistic data - - - - - 6 - 7
V Effect data - - - - - - - - - - - - 8

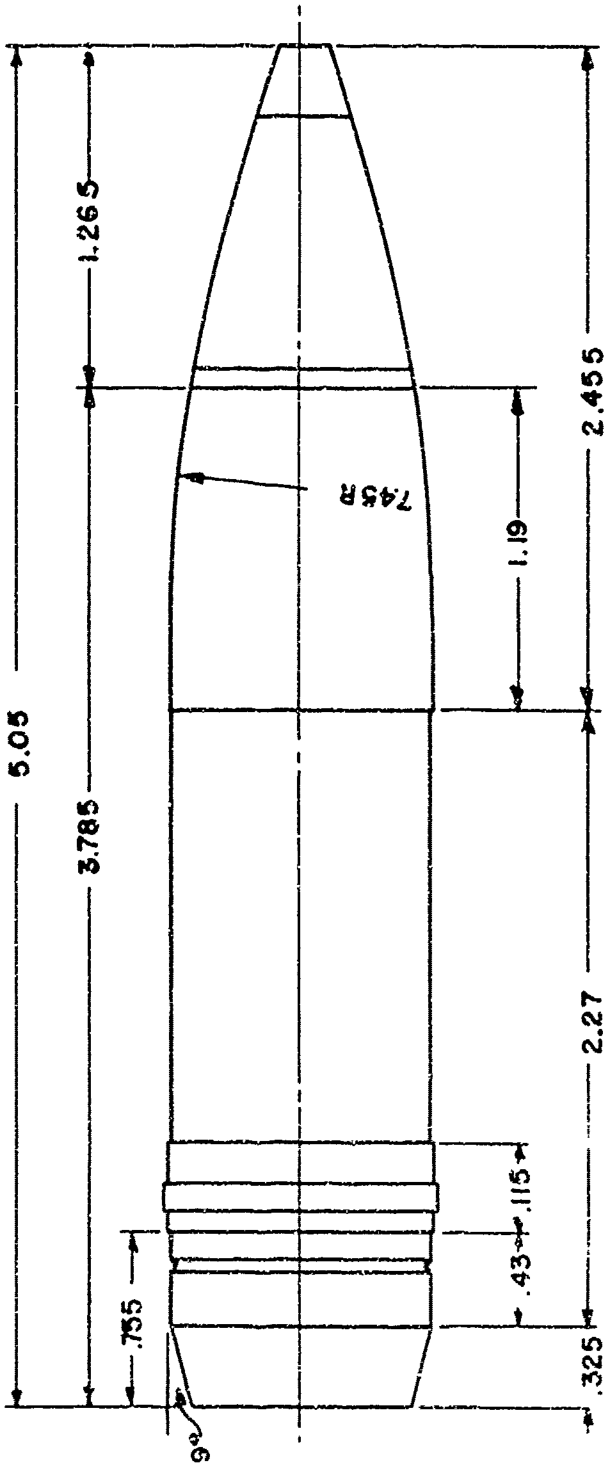
SECTION I

GENERAL

Paragraph
Purpose - 1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 75-mm High Explosive Shell M309 with the Point Detonating Fuze M48A2 or M51A4. This information is collected from the drawings, reports, and firing tables pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 2.953"



SHELL, HE, 75-MM, M309
FUZE, PD, M48A2

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell: Metal parts assembly and details	75-2-365
Booster M21A4: Assembly	73-2-154
Fuze M48A2: Assembly	73-2-140
Details	73-2-143 etc.
Fuze M51A4: Assembly	73-2-145
Details	73-2-143 etc.

3. Dimensions.

Boattail: Angle	9°00'
Length	0.325 cal
Band: Distance from boattail	0.43 cal
Distance from base	0.775 cal
Width	0.115 cal
Cylindrical body: Length	2.27 cal
Ogive: Length	1.19 cal
Radius of arc	7.45 cal
Fuze: Length (outside)	1.265 cal
Length: Shell	3.785 cal
Shell and fuze	5.05 cal
Ogive and fuze	2.455 cal

4. Physical characteristics. The HE Shell M309 is a modification of the HE Shell M48.

Mean weight: Zone 1	14.10 lb
Zone 2 (standard)	14.40 lb
Zone 3	14.70 lb

SECTION III

INTERIOR BALLISTIC DATA

Paragraph
Theoretical yaw in bore - 5

5. Theoretical yaw in bore.

Minimum	5.4 min
Maximum	10.2 min

SECTION IV

EXTERIOR BALLISTIC DATA

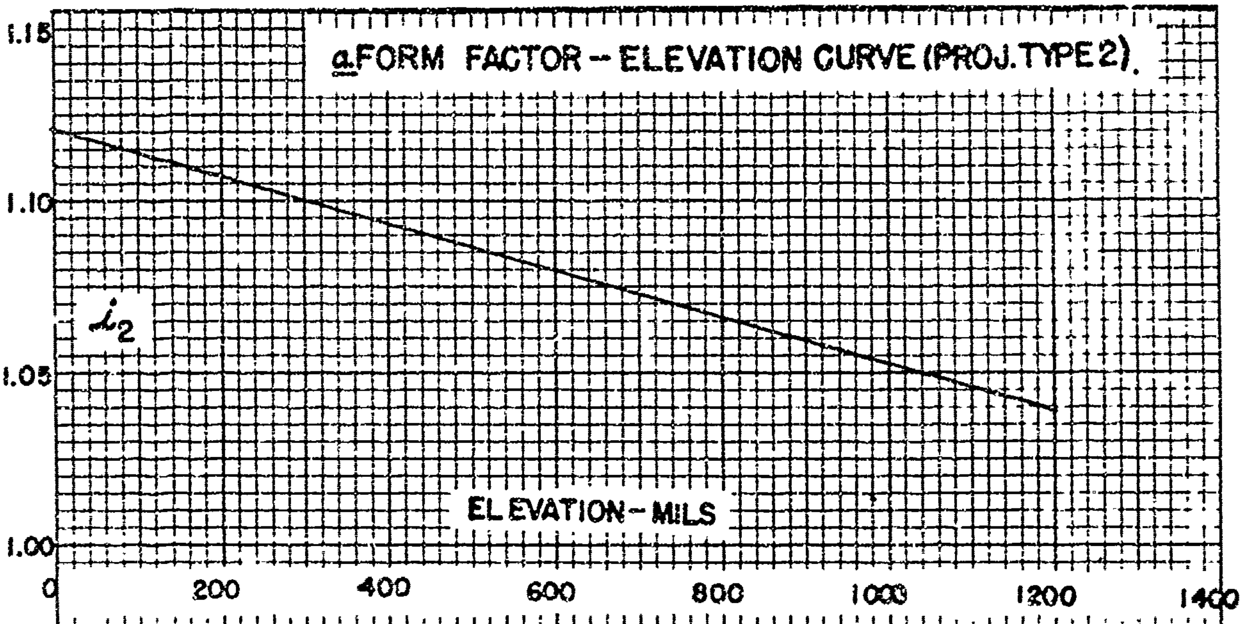
Paragraph
Aerodynamic data - 6
Firing table data- 7

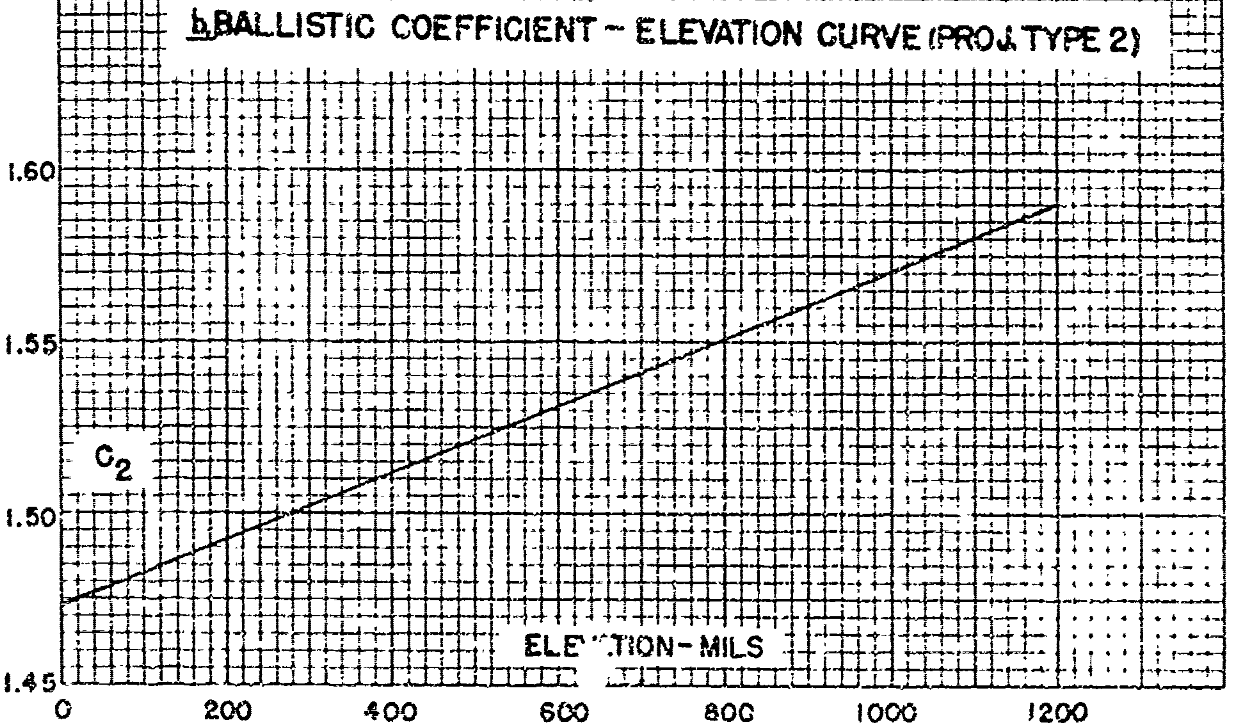
6. Aerodynamic data.

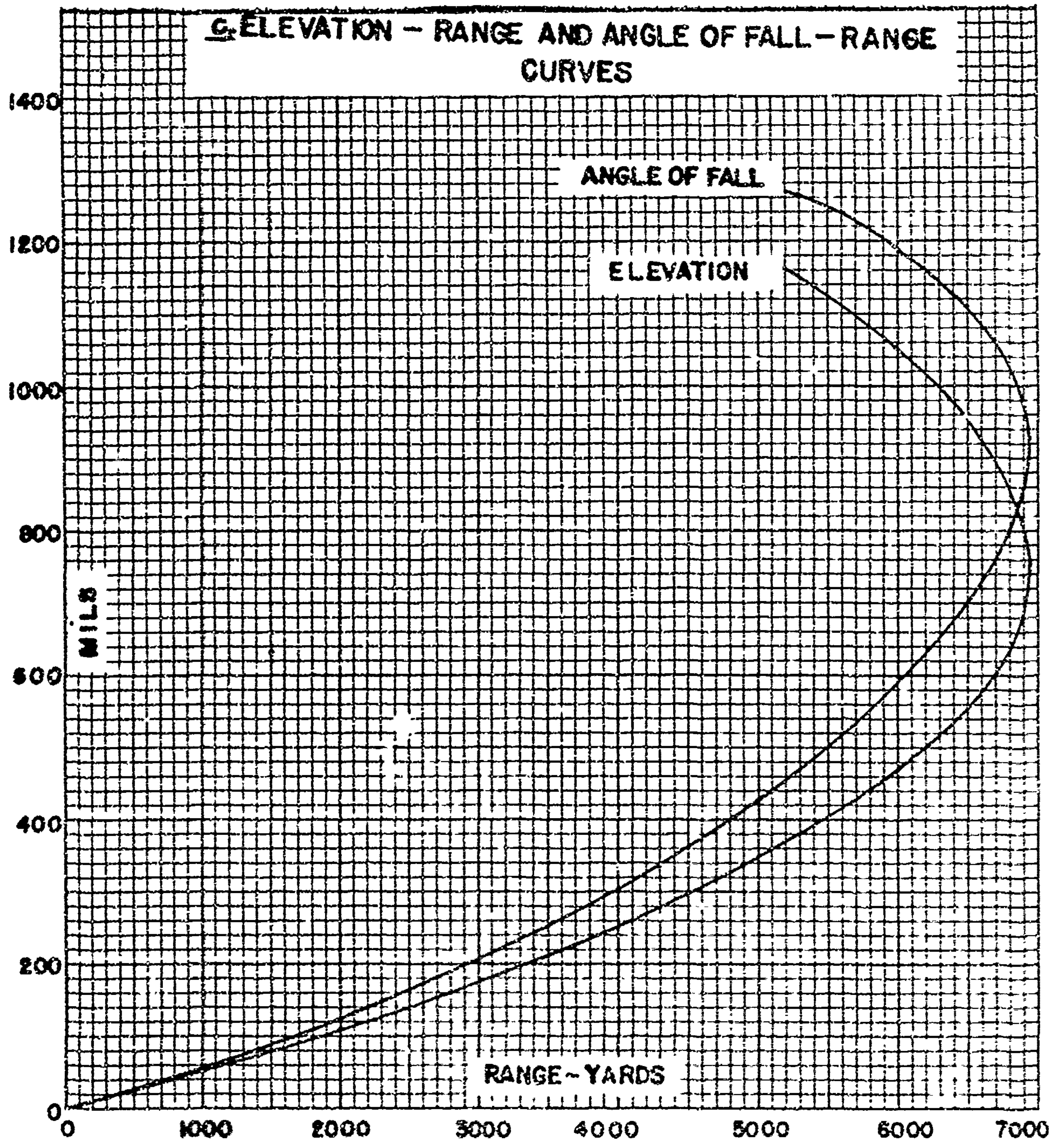
Drag function	G_2
Form factor (from time of flight)	1.08
Ballistic coefficient	1.53
Muzzle velocity	1000 fps
Drag coefficient, K_D	0.077

7. Firing table data. FT 75-BB-1.

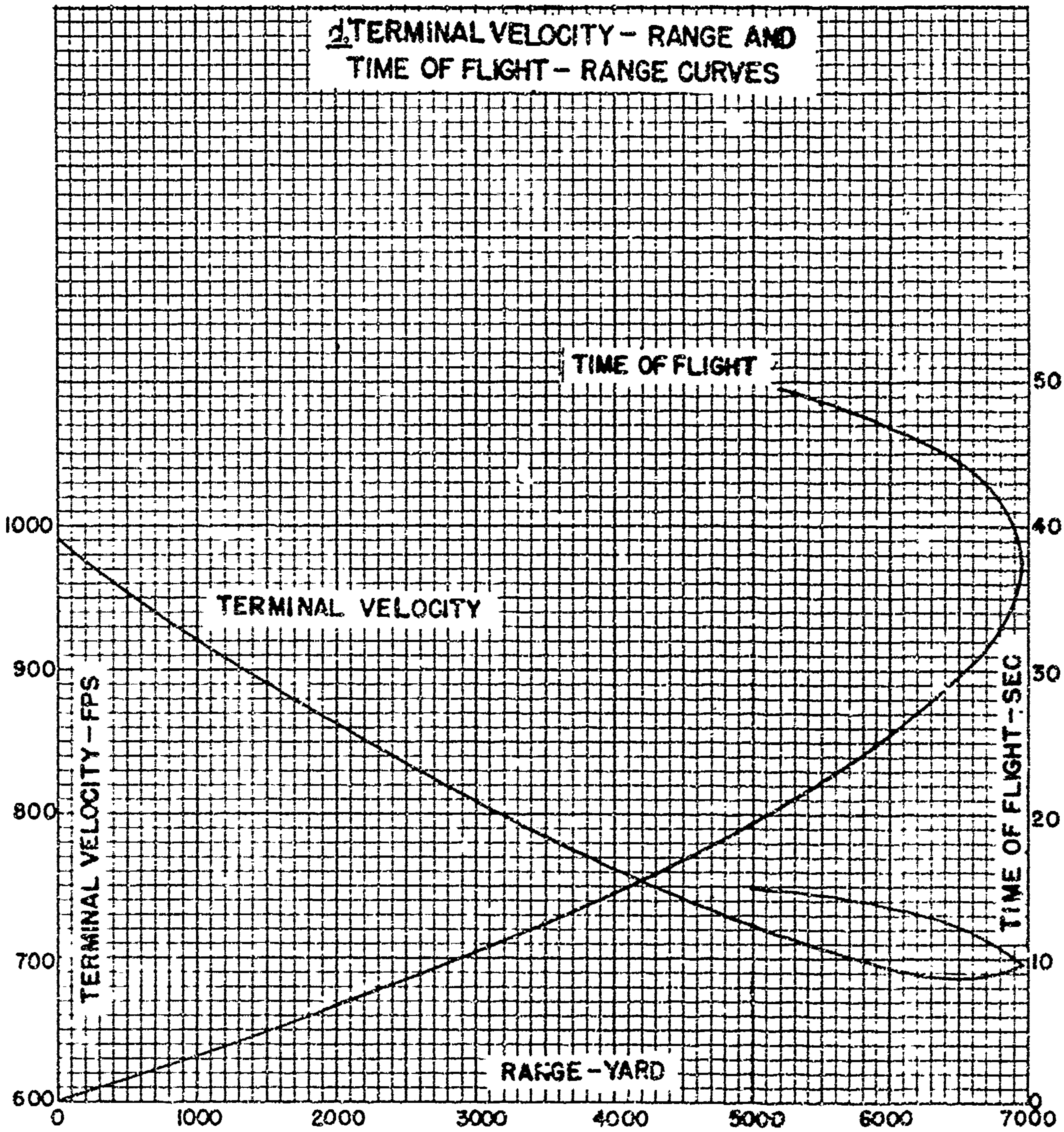
Rifle, 75-mm, M20 (Recoilless). Twist of rifling: 1/22. Projectile weight: 14.40 lb. Muzzle velocity: 990 fps. OCM items 27907 and 28547 recommended and approved standardization of the 75-mm Rifle M20 and the HE Shell M309 with the PD Fuze M51A4. The firing tables are also applicable to the HE Shell M309 with the PD Fuze M48 and modifications of it.

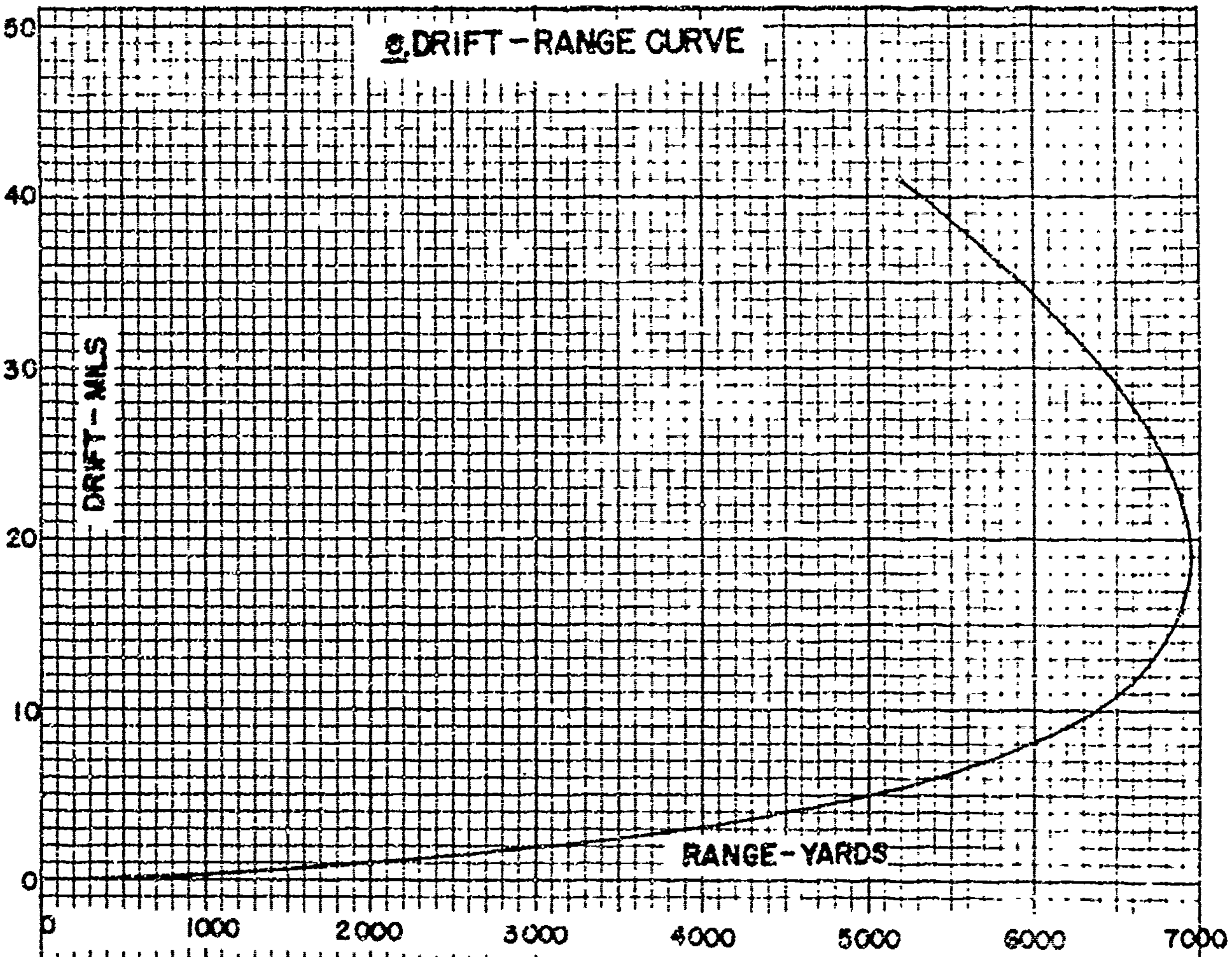

a. FORM FACTOR – ELEVATION CURVE (PROJ. TYPE 2)
i_2
1.15
1.10
1.05
1.00
ELEVATION – MILS
0
200
400
600
800
1000
1200
1400


b. BALLISTIC COEFFICIENT – ELEVATION CURVE (PROJ. TYPE 2)
C_2
1.60
1.55
1.50
1.45
ELEVATION – MILS
0
200
400
600
800
1000
1200

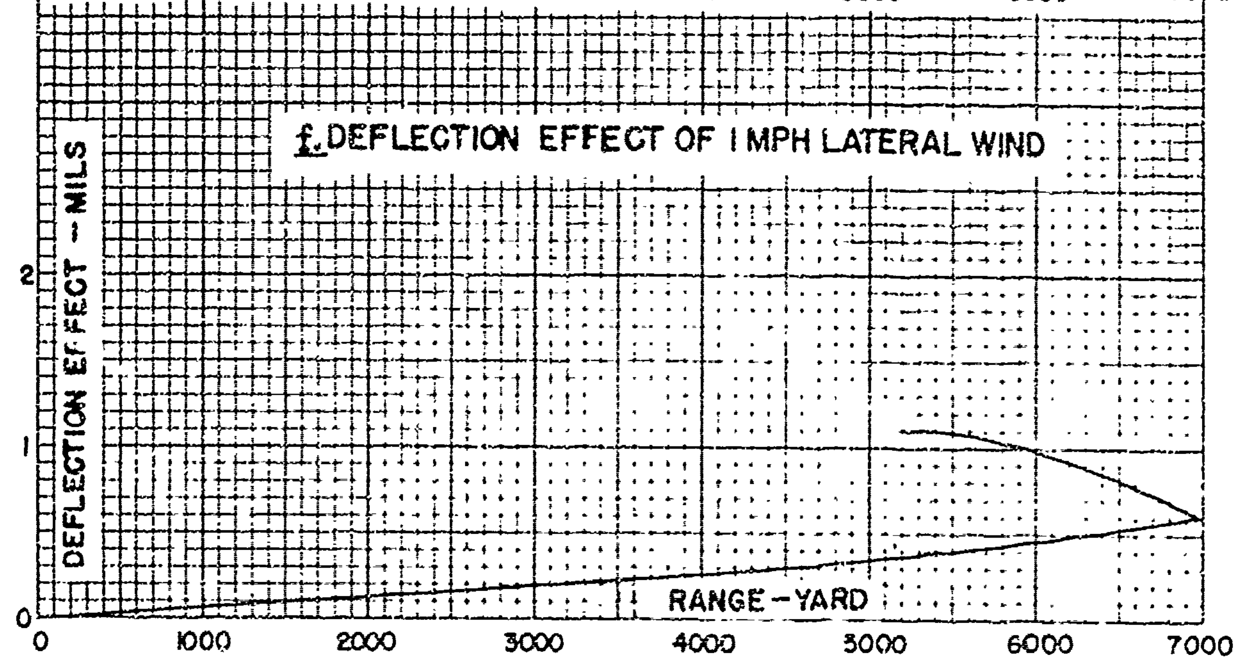


c. ELEVATION – RANGE AND ANGLE OF FALL – RANGE CURVES

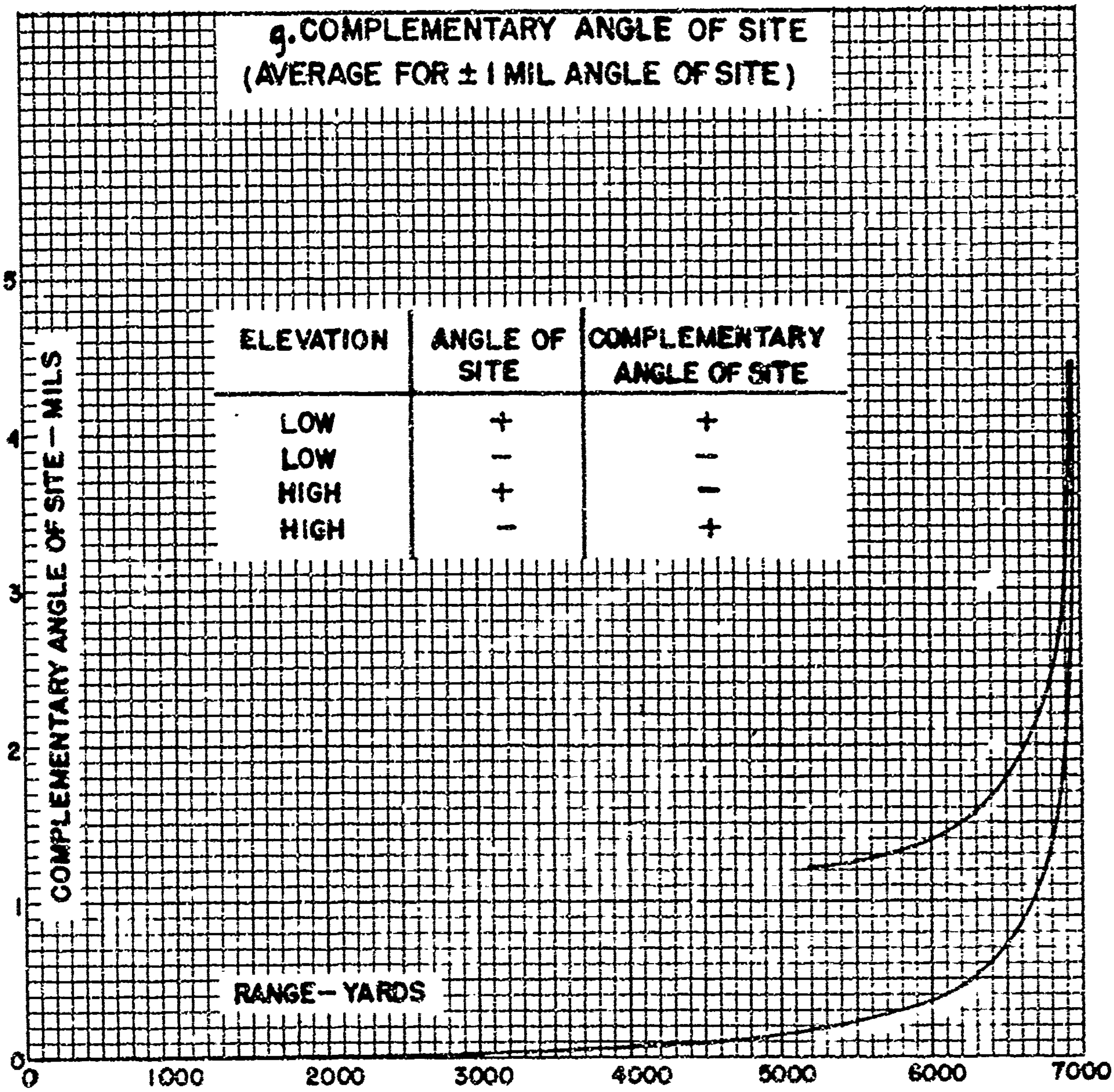

d. TERMINAL VELOCITY - RANGE AND
TIME OF FLIGHT - RANGE CURVES
TIME OF FLIGHT
TERMINAL VELOCITY
TERMINAL VELOCITY - FPS
TIME OF FLIGHT - SEC
RANGE - YARD
1000
900
800
700
600
50
40
30
20
10
0
0
1000
2000
3000
4000
5000
6000
7000



e. DRIFT – RANGE CURVE
DRIFT – MILS
RANGE – YARDS
0
10
20
30
40
50
0
1000
2000
3000
4000
5000
6000
7000

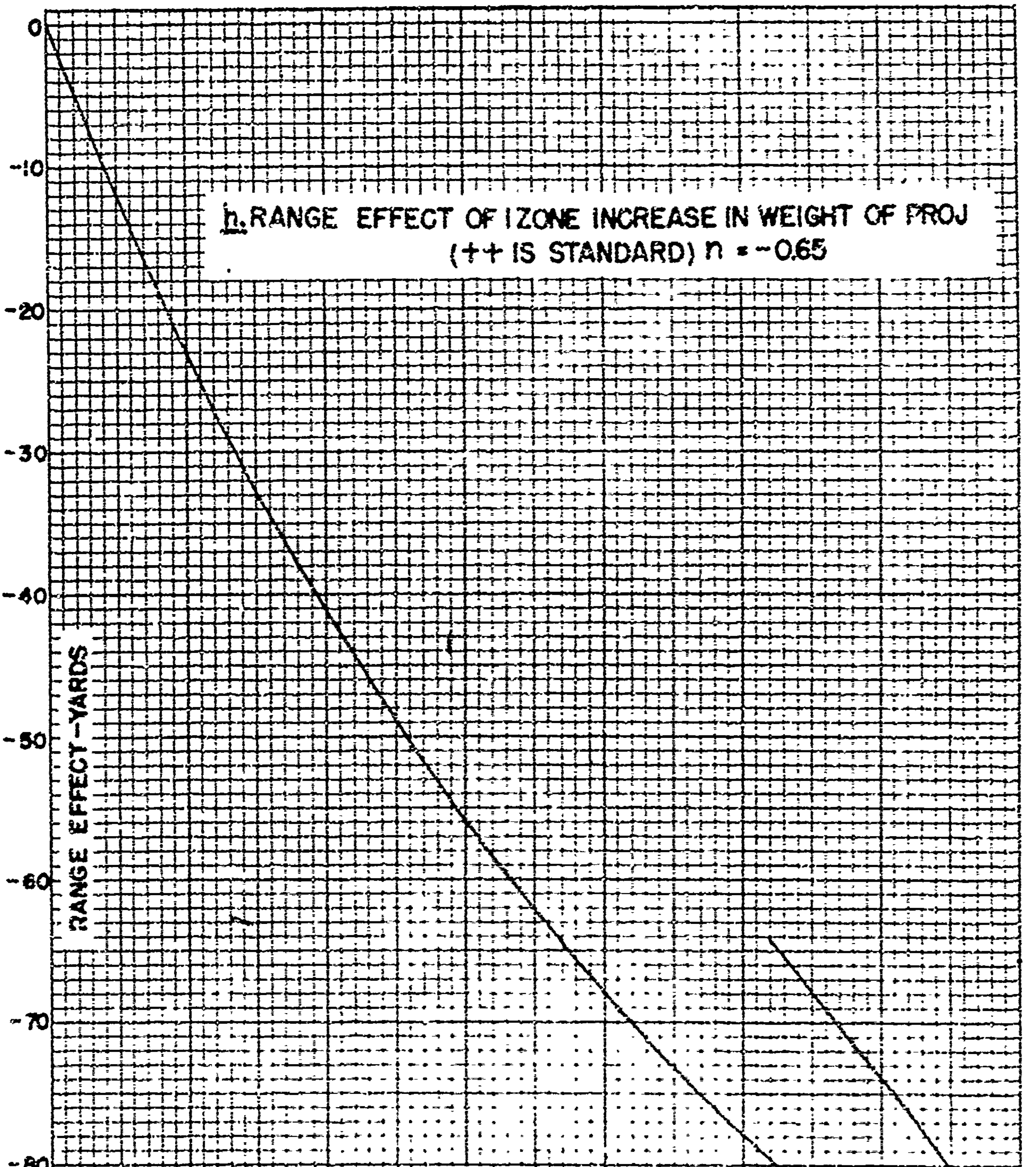


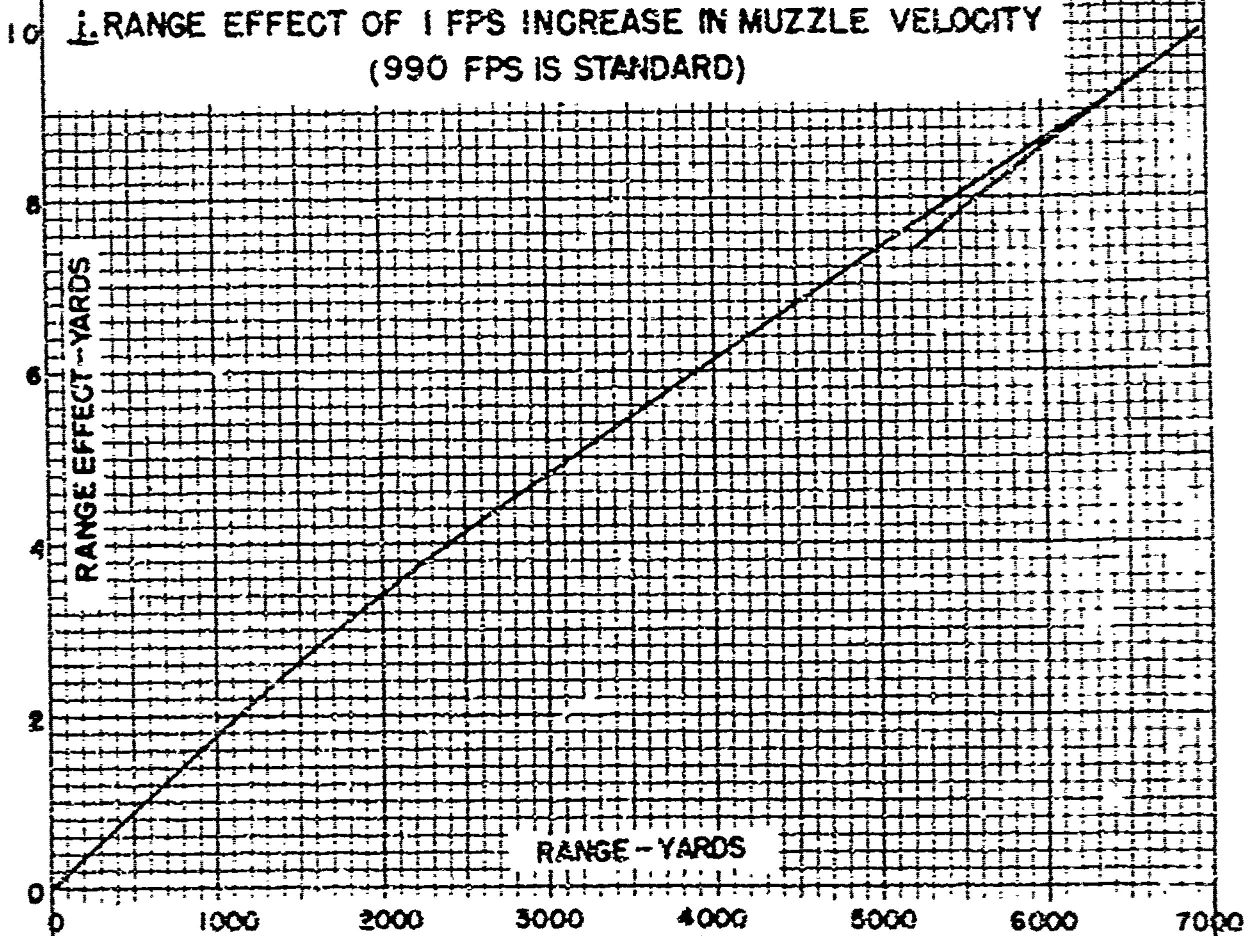
f. DEFLECTION EFFECT OF 1 MPH LATERAL WIND
DEFLECTION EFFECT – MILS
RANGE – YARD
0
1
2
0
1000
2000
3000
4000
5000
6000
7000



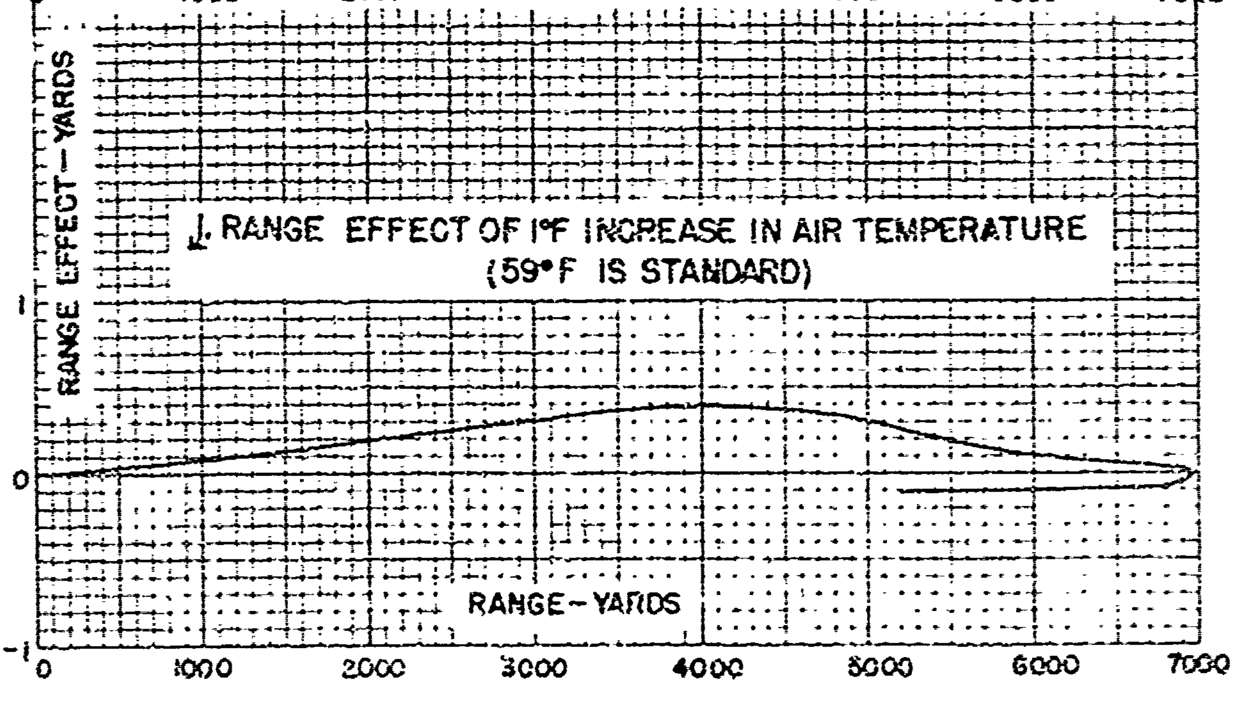
g. COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± 1 MIL ANGLE OF SITE)

ELEVATION	ANGLE OF SITE	COMPLEMENTARY ANGLE OF SITE
LOW	+	+
LOW	−	−
HIGH	+	−
HIGH	−	+

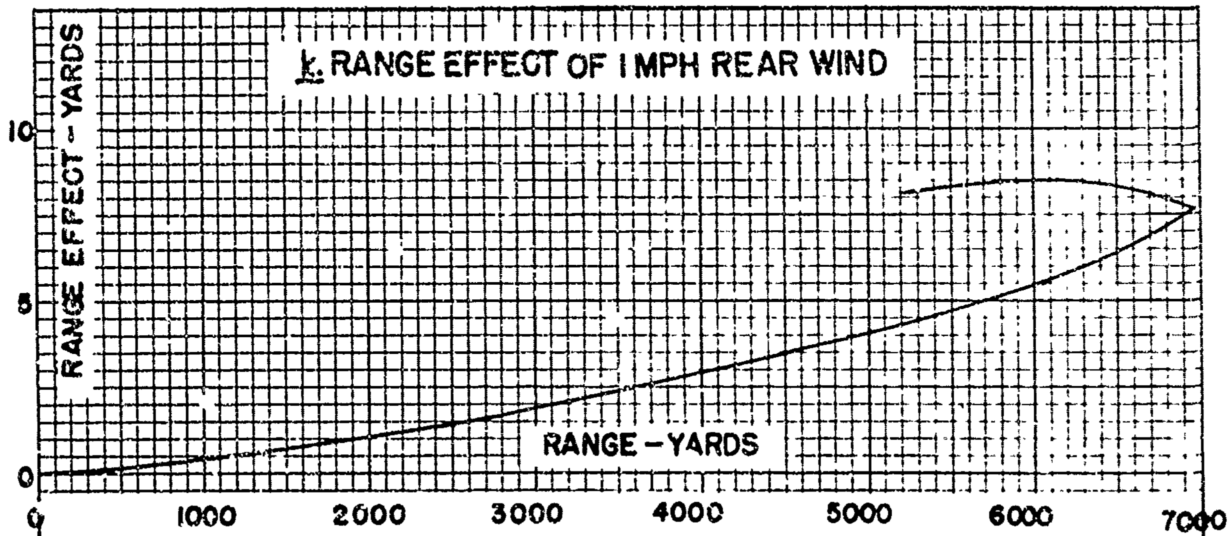

h. RANGE EFFECT OF 1 ZONE INCREASE IN WEIGHT OF PROJ
(++ IS STANDARD) n = -0.65
RANGE EFFECT-YARDS
RANGE-YARDS
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
0
1000
2000
3000
4000
5000
6000
7000



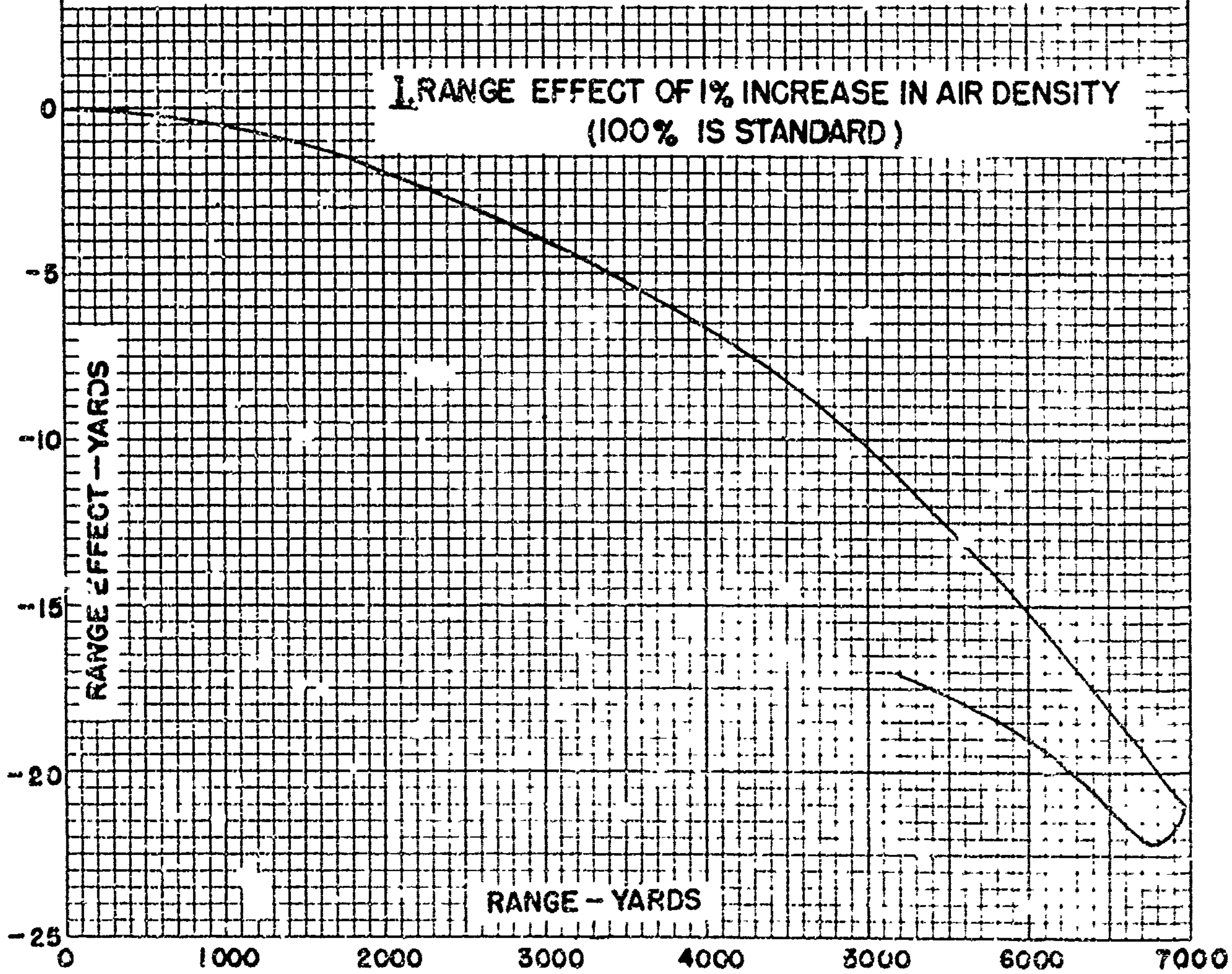
I. RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY
(990 FPS IS STANDARD)



J. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE
(59°F IS STANDARD)



k. RANGE EFFECT OF 1 MPH REAR WIND



l. RANGE EFFECT OF 1% INCREASE IN AIR DENSITY (100% IS STANDARD)

SECTION V

EFFECT DATA

Paragraph
Fragmentation - 8

8. **Fragmentation.** The fragmentation of the HE Shell M309 should be approximately the same as that of the HE Shell M48, of which it is a modification. For data on fragmentation of the M48 Shell, see BRLH 75-1-48.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 75-1-310

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
8 March 1949

# BALLISTIC AND ENGINEERING DATA
for
Shell, HEAT, 75-mm, M310
with
Fuze, BD, M62A1 or M91

Section		Paragraph
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5
IV	Exterior ballistic data	6 - 7
V	Effect data	8

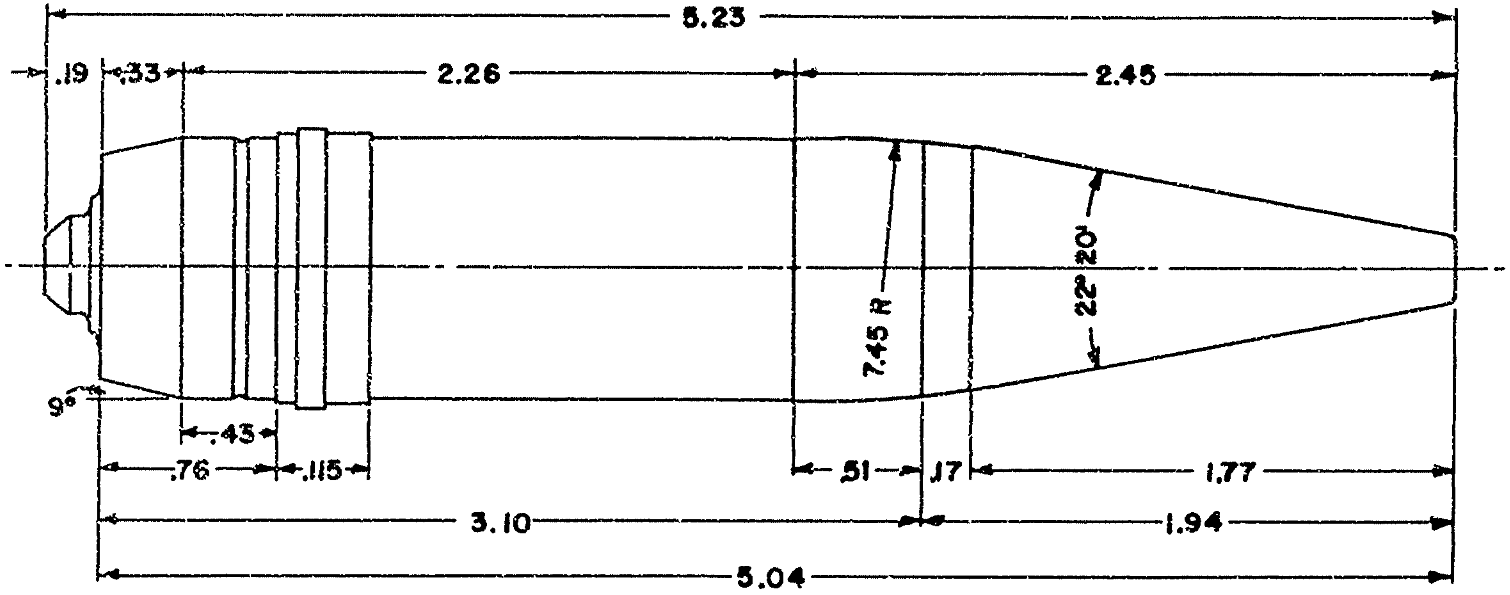
SECTION I

GENERAL

	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 75-mm High Explosive Antitank Shell M310 with the Base Detonating Fuze M62A1 or M91. This information is collected from the drawings, reports, and firing tables pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 2.953"



SHELL, HEAT, 75-MM, M 310
FUZE, BD, M91

SECTION II

DESCRIPTION

Paragraph

Drawings - 2
Dimensions - 3
Physical characteristics - 4

2. Drawings.

Shell:	Metal parts assembly and details	75-2-366
	Ogive assembly, cone and details	75-2-315
Fuze, BD, M62A1:	Assembly	73-2-168
	Details	73-2-169 170 and 171
Fuze, BD, M91:	Assembly	73-2-239
	Details	73-2-169, 170 and 240

3. Dimensions.

Fuze, BD, M91:	Length (outside)	.19 cal
Boattail:	Angle	9°00
	Length	0.33 cal
Band:	Distance from boattail	0.43 cal
	Distance from base	0.76 cal
	Width	0.115 cal
Body:	Length of cylindrical part	2.26 cal
	Length of ogival part	0.51 cal
	Radius of arc	7.45 cal
Union:	Length	0.17 cal
Ogive:	Length	1.77 cal
	Angle	22°20'
Length:	Body	3.10 cal
	Ogive and union	1.94 cal
	Shell	5.04 cal
	Ogive, union, and ogival part of body	2.45 cal
	Shell and Fuze M91	5.23 cal

Note: Fuze, BD, M62A1 is entirely inside of shell body.

4. Physical characteristics. The HEAT Shell M310 is a modification of the HEAT Shell M66. Its standard weight is 13.08 lb.

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore	5

5. Theoretical yaw in bore.

Minimum	5.4 min
Maximum	10.3 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	6
Firing table data	7

6. Aerodynamic data.

Drag function	G_2
Form factor (from time of flight)	1.23
Ballistic coefficient	1.22
Muzzle velocity	1000 fps
Drag coefficient, K_D	0.087

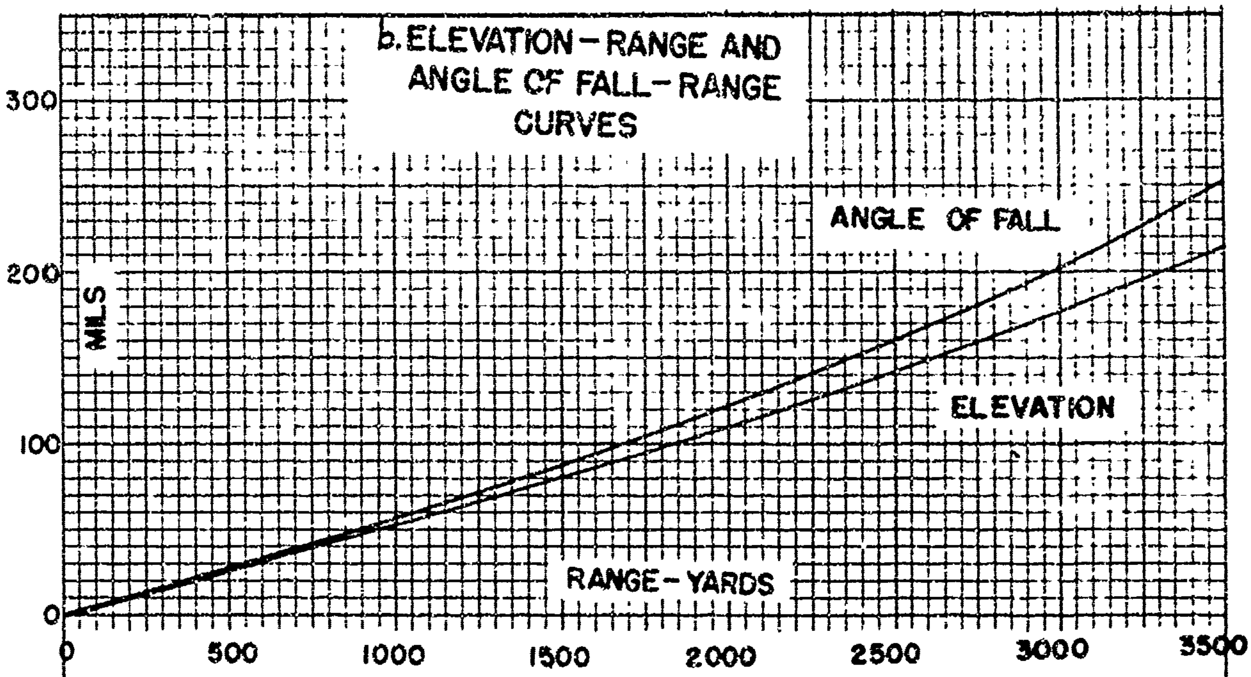
7. Firing table data. FT 75-BB-1.

Rifle, 75-mm, M20 (Recoilless). Twist of rifling: 1/22. Projectile weight: 13.1 lb. Muzzle velocity: 1000 fps. OCM items 27907 and 28547 recommended and approved standardization of the 75-mm Rifle M20 and the HEAT Shell M310.

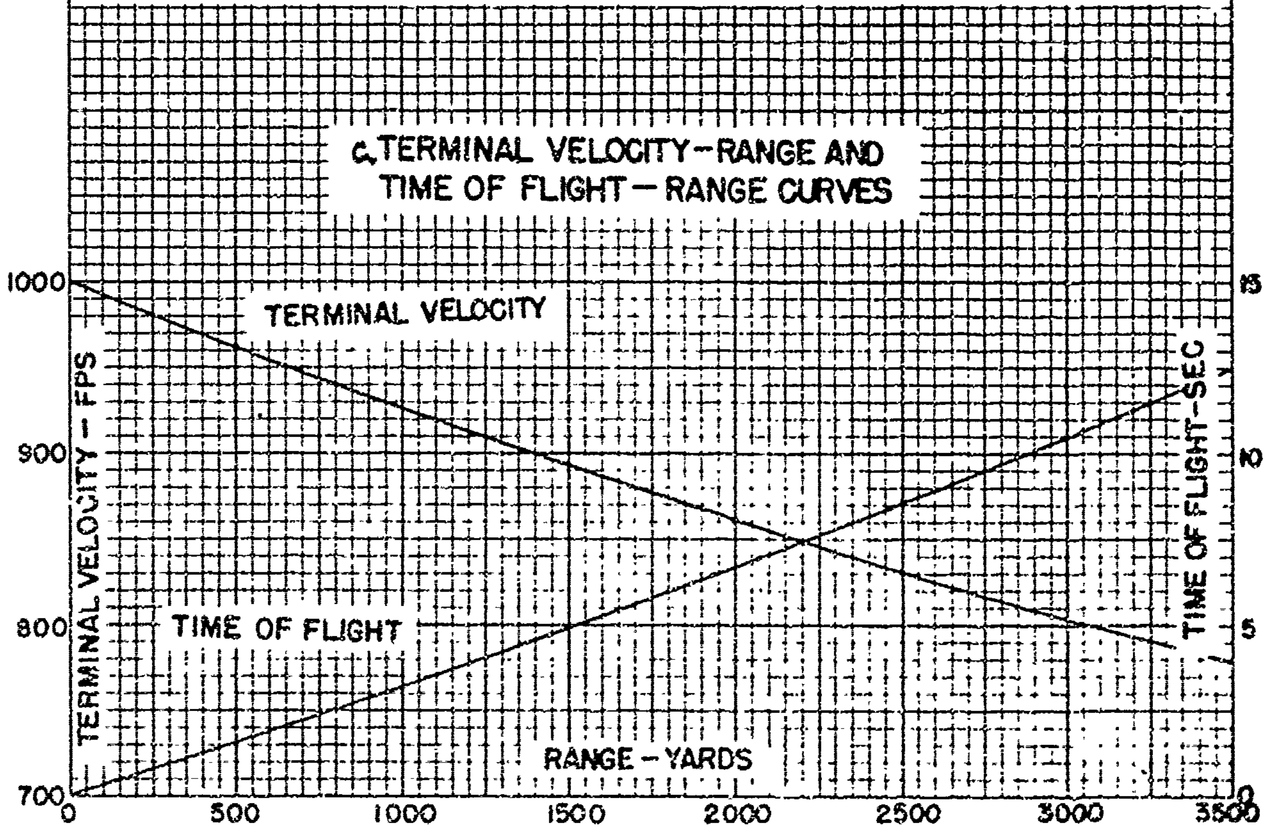
a. Form factor and ballistic coefficient (Proj Type 6). The following values apply at all elevations:

$i_6 = 0.84$

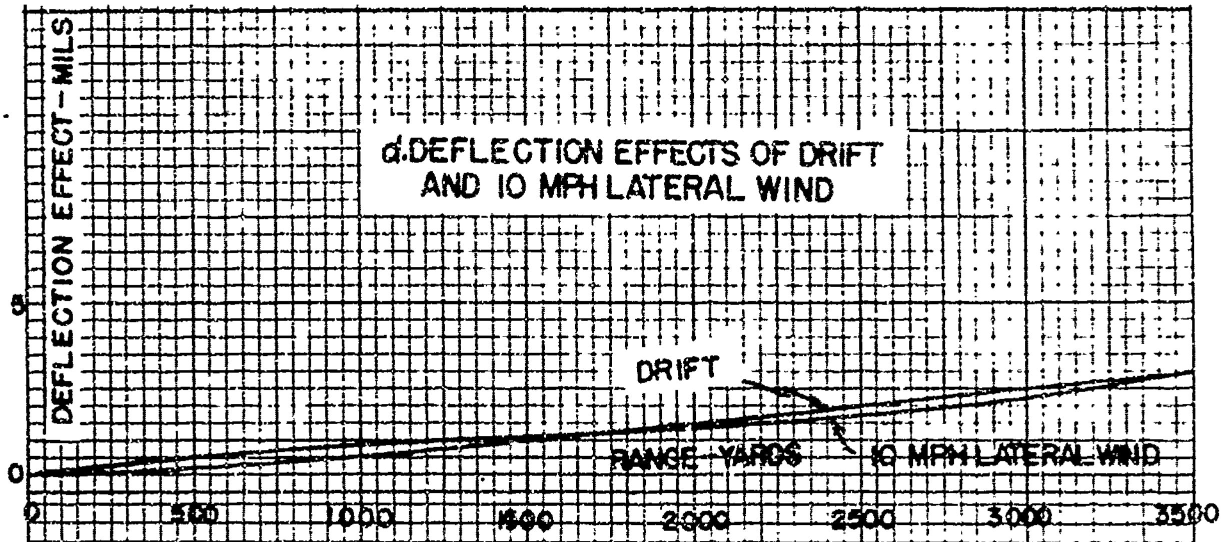
$C_6 = 1.781$



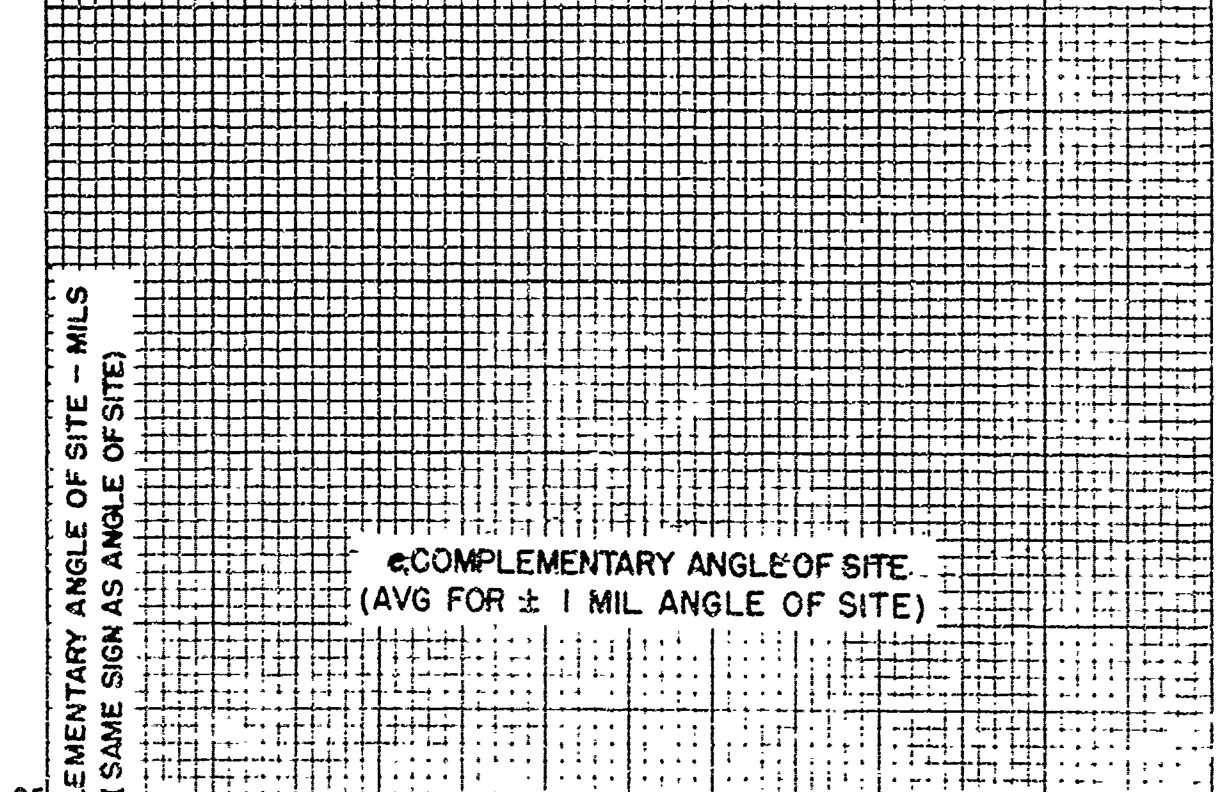
b. ELEVATION – RANGE AND ANGLE OF FALL – RANGE CURVES



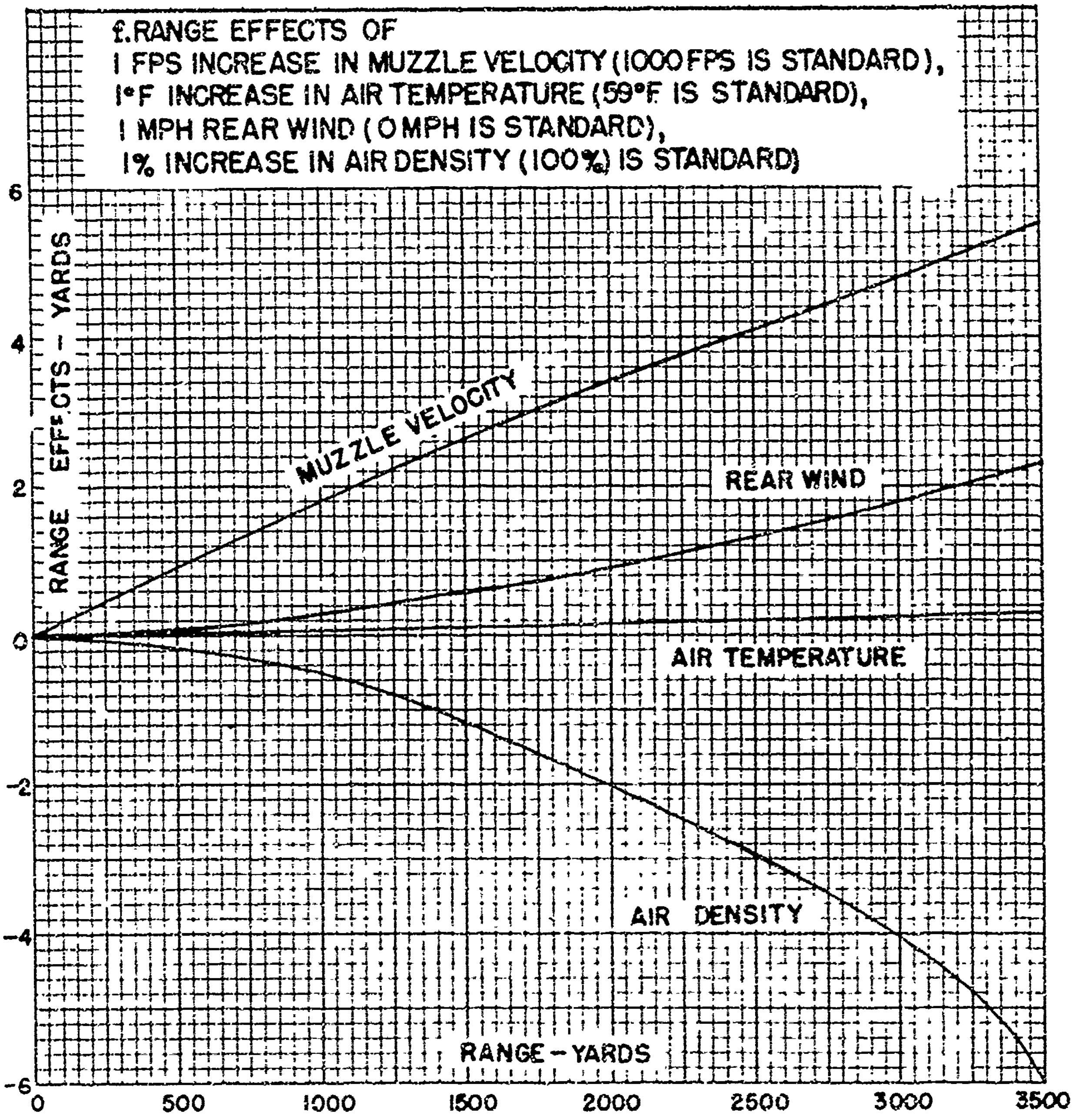
c. TERMINAL VELOCITY – RANGE AND TIME OF FLIGHT – RANGE CURVES



d. DEFLECTION EFFECTS OF DRIFT AND 10 MPH LATERAL WIND



e. COMPLEMENTARY ANGLE OF SITE
(AVG FOR ± 1 MIL ANGLE OF SITE)



f. RANGE EFFECTS OF
1 FPS INCREASE IN MUZZLE VELOCITY (1000 FPS IS STANDARD),
1°F INCREASE IN AIR TEMPERATURE (59°F IS STANDARD),
1 MPH REAR WIND (0 MPH IS STANDARD),
1% INCREASE IN AIR DENSITY (100% IS STANDARD)

SECTION V

EFFECT DATA

Paragraph

Penetration - 8

8. **Penetration.** The average penetration of homogeneous armor plate by 75-mm HEAT Shell M310 is 3 inches.

[redacted]